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Report of the Working Party on Sewage Disposal

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REPORT OF THE WORKING PARTY ON SEWAGE DISPOSAL

To the Right Honourable Anthony Greenwood M.P.

Minister of Housing and Local Government

and

To the Right Honourable George Thomas M.P.

Secretary of State for Wales

Chairman's Foreword

This report is called "Taken for Granted" because, in spite of growing contemporary interest in all forms of pollution, the disposal of sewage *is* taken for granted as long as it is effective and unnoticeable. Protests are made about failures, but no praise arrives for success—as many under-valued workers at all levels know too well.

Although we were aware that dealing with sewage is an integral part of the larger problem of disposing of the increasing waste and rubbish of modern civilisation, we have of course limited our detailed considerations to our allotted task. But it cannot be considered in isolation—this is especially true in thinking about the career structure, the straddling of conventional disciplines, the international aspects. I recall, for instance, discussing with a French engineer the usefulness of longer outfalls to prevent sewage contamination of beaches. "That's alright", he said, "as long as your outfalls aren't so long that we get your problems, or our outfalls so long that we send you ours".

This report has been produced comparatively quickly in order that it may form part of the basis for current consideration of measures to improve our enviroment. We could have taken longer and written more—the last Royal Commission on Sewage sat from 1898 to 1915. But the available facts quickly became clear and form the basis of our recommendations. There is, however, no finality in the report—it is not intended as a once and for all reference book. One of our difficulties has been an absence of basic data and there is clearly a need for continuing studies in preference to future reliance on ad hoc investigations.

Most of our laws and attitudes to sewage disposal derive from a sanitary approach—from the need to avoid dangers of disease and obnoxious nuisance. But even work based on these premises was not always immediately acceptable. When Chadwick was trying to deal with the water and sewage problems of foul London in 1854 the Times commented on August 1:

> " We prefer to take our chance of cholera and the rest than be bullied into health. There is nothing a man hates so much as being cleaned against his will—It is a positive fact that many have died of a good washing, as much from the irritation of the nerves as from the exposure of the cuticle, no longer protected by dirt."

Now the aspect of cleanliness is completely taken for granted and there is a shift of emphasis from disease phobia towards conjoined amenity and aesthetic values. People want more than reassurances of safety from disastrous germs—they want clean beaches and clear rivers and shining fish. This livelier attitude needs only to be accompanied by a publicly-accepted increase in expenditure of expertise and money. At present we spend about 0.5% of our gross national product on sewerage and sewage disposal; an average of 0.8d per person per day on sewage treatment; and the local rate in the pound spent on sewage varies from 5/11 in one authority to one penny in another.

The term "sewage disposal" suggests primarily the process of getting rid of sewage. But the second new element in the situation is that we cannot simply dispose of sewage as unwanted waste. Growing demands for water make inevitable the increased use of treated sewage effluent in order to meet supply problems.

So there is now a threefold aspect. To the basic sanitary considerations must be added the amenity demands of a more aware society and the apparently insatiable thirst of industry and individuals. These combine to transform a Cinderella of the public services into a matter of urgent concern. The problem cannot be washed or wished away. Nor can its solution any longer be taken for granted.

Lena Jeger.

Introduction

Gentlemen,

1 We were appointed in February 1969 "to consider and report on the public health, amenity and economic aspects of the various methods of sewage disposal". Our working definition of sewage has been "the liquid waste of the community". We have therefore considered within our terms of reference the liquid wastes from domestic, industrial, agricultural and transport sources.

2 We have come to the conclusion that the rapid growth of the volume and the changing composition of sewage will destroy valuable natural assets in our rivers and coastal waters unless there is a much greater effort to control water pollution.

3 The fast-increasing consumption of water, domestically and industrially, makes imperative a higher incidence of re-use, and therefore compels stricter control over the quality of water returned to rivers.

4 We are glad of the opportunity to make known more widely the already considerable achievements in controlling water pollution in this country. It is fortunate that there are in Britain people and organisations with the knowledge and experience necessary for further control. We are confident that there is no lack of scientific understanding of the problem of pollution. The inescapable changes need to be in financial priorities, administration, enforcement, and in public attitudes.

5 We include in our review discharges to public sewers, watercourses, underground strata, to the land, to estuaries and to the sea; and the disposal of liquid waste within the curtilage of industrial premises or farms.

6 The working party have held 17 full meetings. We have spent 21 days in visits to sewage treatment works and to sewage outfalls and discharging points in different areas in England and Wales; and to the Water Pollution Research Laboratory and the Water Resources Board. Some members in addition visited the International Exhibition of Sewage Plant Manufacturers at Munich, and investigated methods of sewage disposal in Sweden. The working party are most grateful to all the people in the local authorities and other organisations who enabled us to benefit from their experience of methods of sewage disposal and water pollution control.

7 The working party are also grateful for the evidence submitted, which we have considered carefully. Written evidence was received from about 80 organisations and individuals listed in Appendix 1. We welcomed this evidence of widespread interest in our work.

8 We wish to record our appreciation of the outstanding services of our Administrative Secretary Mrs. J. Ash and of our Technical Secretary Mr. G. A. Truesdale. We realise that such expressions of thanks can appear routine in official reports. But in this case the working party unanimously wishes to emphasise its awareness of the high standard of professional assistance which it has enjoyed.

9 We have pleasure in submitting our report.

Lena M. Jeger	Peter C. G. Isaac
Shirley Anglesey	John Knowelden
T. W. B. Beddow	W. F. Lester
Peter Black	Donald J. H. Payne
Henry Brinton	Ian Percival[1]
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G. T. Heckels	W. Wroe[2]

March 1970

[1]Signed subject to reservations on pages 54–55
[2]Signed subject to reservations on page 55.

Chapter 1 How water is used and managed

10 Sewage is the liquid waste of the community. Because 99·9% of it is water, its disposal is an integral part of the water cycle.

The increasing volume of water used

11 The volume of water used is rising at the rate of about 3% per year[1]. The volume of sewage effluent has consequently been increasing at about the same rate.

12 At present the volume of water used daily in England and Wales (exclusive of water abstracted for cooling purposes), amounts to about 5,000 mil gal (23 mil m^3)[1] or about 95 gal. (430 1) per person per day. Domestic use accounts for nearly 1,800 mil gal (8 mil m^3) of this daily average total[1]. The remainder is used for industrial purposes and in agriculture. According to the evidence of the Ministry of Technology (which draws on the work of the Water Pollution Research Laboratory) most of the water used domestically and about 1,500 mil gal (6·8 mil m^3) used by industry each day is discharged to sewers, making a total daily flow of sewage of around 3,100 mil gal (14·1 mil m^3) or 60 gal per person per day.

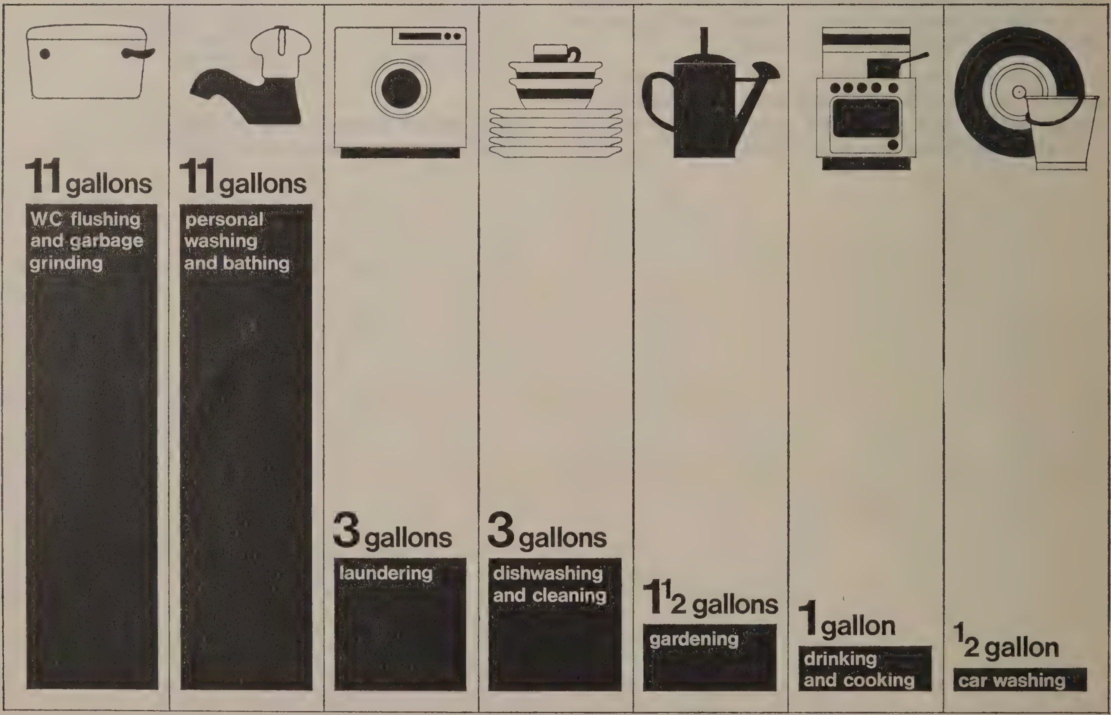

DIAGRAM 1 Average domestic consumption of water per head per day (figures for 1967 based on estimates by the Water Resources Board)

13 As slums are being replaced by well-equipped homes and as older houses are being modernised, more water is used in bathrooms and kitchens. We anticipate an increase in the rate of water use from these advances. The greater use of domestic labour-saving equipment such as clothes washing machines, dishwashing machines and kitchen sink garbage grinders also increases the use of water. So does the growing number of cars. People today use more disposable goods eg tissues, tampons, napkins, which are flushed into sewers as an additional load on their capacity, often planned many years ago for a different standard of living. The demands of industry for water are also expected to increase and overall it is estimated that by the end of the century about twice[2] the volume of water now used will be needed and twice the amount of liquid waste will have to be discharged.

14 Although the amount of rain falling in this country is considerable (some six times the total volume abstracted) half is lost by evaporation, transpiration by plants and run-off to the sea. Readily accessible supplies will soon be fully exploited[2]. About one third of the public water supply comes from natural upland lakes or water impounded in the upper reaches of rivers; a third comes from underground sources and a further third direct from rivers[3]. Sewage effluent is a significant proportion of the volume of many rivers whose water is now used for public supply, or which may be needed for water supply as the demand presses on our limited resources. We cannot keep some of our rivers flowing in dry weather without returned sewage effluent.

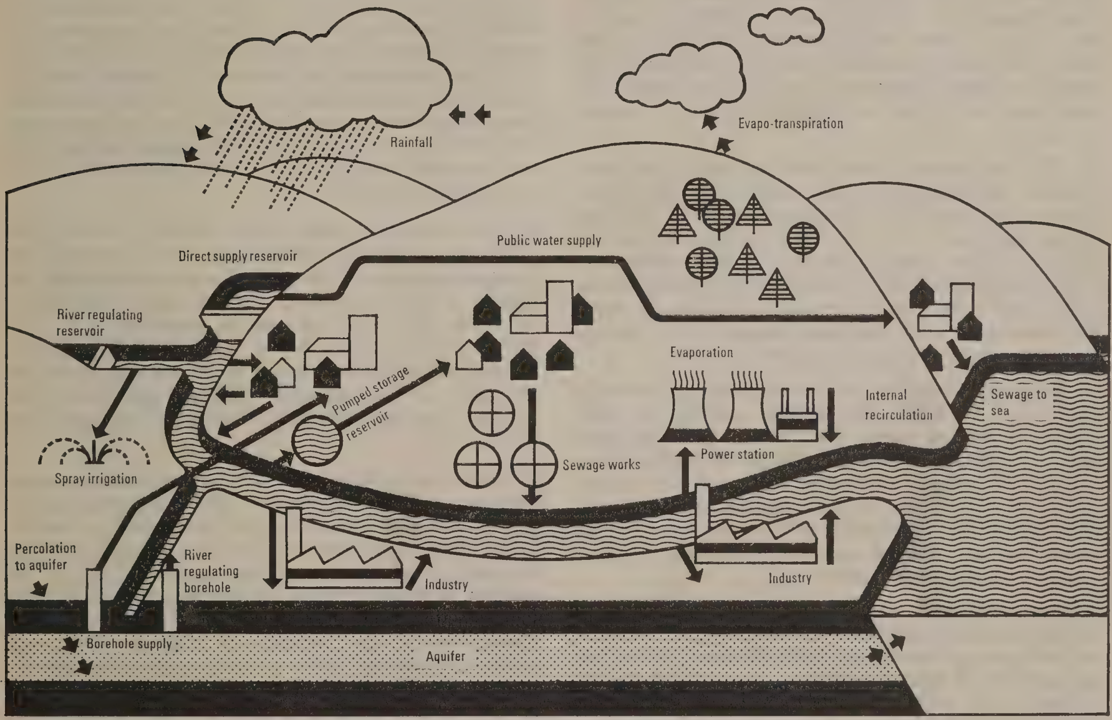

DIAGRAM 2 The hydrological cycle

15 Sewage from about 40 million people in England and Wales is drained to treatment works and then discharged to rivers or estuaries; sewage from about 6 million people is discharged to the sea or estuaries. About 3 million people are in homes not connected to main drains. (Evidence from the Ministry of Technology).

Management of water and sewage

16 The present management of water and sewage by public agencies originated as part of the public health measures which were necessary to create conditions in which people could survive in the rapidly growing towns during the last century.

17 Public health legislation requires statutorily controlled water undertakers to supply wholesome water to the public, and local health authorities to verify its wholesomeness. People are thus protected from water-borne disease but now expect abundant as well as clean water from the tap. About 99 per cent of the population enjoy the convenience of water from the mains. Modern industry also requires plentiful water for its development. Public policy on water supply is therefore not now based only on the needs of public health. The increase in the demand for water has led to the recognition of the necessity for a national policy to conserve this vital natural resource.

18 The Water Act 1945 gave the Minister of Health the duty to promote the conservation and proper use of water resources. The Water Resources Act 1963 extended this responsibility, now resting with the Minister of Housing and Local Government. Twenty-nine river authorities were created to administer the new function of water conservation. They were given powers to licence and charge for all abstractions from surface or underground water. They are also responsible for freshwater fisheries, land drainage and pollution prevention. The 1963 Act, which set up the Water Resources Board, also charged it with the duty of advising the Minister and the river authorities on their water conservation functions. The river authorities are required to assess the water resources in their areas and to draw up a plan for meeting the estimated future demand for water.

19 Thus Parliament has recognised the need to plan ahead to secure the quantity of water required in the future. Government policy has also been concerned with the efficient distribution of water. The number of statutory undertakers has been reduced from over a thousand in 1945 to 192 in England and 42 in Wales in 1969. Local authorities supply under a third of the water distributed by the statutory undertakers, while joint boards supply nearly half and statutory companies nearly a quarter.

20 While there has been deliberate policy by successive governments to supply the essential quantity of water required in modern society, there has not been the same clarity of intention or effect in the achievement of high standards of sewage treatment and disposal. Our studies show that the *quantity* of water now demanded by the public cannot be met without higher *quality* standards for returned effluent, which is essential to maintain the minimum volume for modern needs.

21 The traditional purpose of sewage treatment—to avoid pestilence and nuisance—has not in the past required such stringent and consistent standards as are needed for the treatment of water for drinking. Sewage disposal and sewerage has remained solely a local government responsibility, administered by about 1,400 authorities comprising the Greater London Council, the councils of boroughs, urban or rural districts or joint boards of these. The largest authority (the GLC) has a population of nearly 8 million and the smallest has 1,460 people. Many authorities are too small to be able to employ qualified staff and lack the resources to allow expenditure on effective methods of sewage disposal.

22 The cost of sewage disposal and sewerage is now most unevenly distributed. Expenditure varies from £6 17s per head per annum to 3s 2d. The rate in the £ for sewage disposal and sewerage varies from 5s 11d to 1d. (See Appendix 2).

23 The sewage disposal authorities are responsible for making "such provisions by means of sewage disposal or otherwise as may be necessary for effectually dealing with the contents of their sewers" (Public Health Act 1936). Trade waste may be discharged into the public sewers, subject to conditions imposed by the local sewage disposal authorities. Traders may be required to pay charges to cover the cost of the reception and disposal of their trade effluent [Public Health (Drainage of Trade Premises) Act 1937 and Public Health Act 1961].

24 There is no definition of effective sewage disposal though section 31 of the Public Health Act 1936 requires local authorities to discharge their sewage disposal functions without creating a nuisance. There may, however, be little incentive to an authority for expenditure on sewage disposal, because the benefits may be enjoyed more by downstream users of rivers, or holidaymakers, than by an authority's own ratepayers. This was no doubt one reason why Parliament gave the control of discharges to rivers and estuaries to river authorities, who are now responsible for the whole length of their rivers.

25 The legal powers of control over discharges to rivers distinguish non-tidal rivers from tidal rivers and estuaries. Only the former are used for public water supply and the volume of water for dilution of discharges is greater in the latter. The Rivers (Prevention of Pollution) Acts 1951 and 1961 for "maintaining or restoring the wholesomeness of rivers" apply only to *non-tidal* rivers. The river authorities have comprehensive powers to fulfil this aim by licensing and attaching conditions to all discharges, whether from sewage treatment works owned by local authorities or from industrialists and farmers.

26 The river authorities' general power of control over discharges to *tidal rivers and estuaries* is however restricted to *new* or substantially altered discharges occurring after the passage of the Clean Rivers (Estuaries and Tidal Waters) Act 1960. All discharges can be controlled if a Tidal Waters Order is made. But so far only 14 Tidal Waters Orders have been made, and these do not include any for the major polluted estuaries. All discharges to the tidal Thames have been controlled under local legislation since 1968.

27 As it has for long been assumed that the sea provided adequate dilution for discharges, there has been no general control over discharges to the sea, though the Sea Fisheries Committees have powers to control the discharge or dumping by industry of substances harmful to sea fish or sea fisheries. New local authority outfall schemes, which require loan sanction from the Ministry of Housing and Local Government or the Secretary of State for Wales, are examined to ensure, as far as possible, that the proposed disposal arrangements will avoid risk to public health or amenity. Where existing arrangements are unsatisfactory there is no specific power to insist on improvement.

28 The river authorities exercise their responsibilities for water conservation and river management in three main ways. They can themselves conserve water supplies. They have power to control abstractions from surface and underground water. They can control the quality of water through their power to license discharges, but not as effectively as they can control the quantity. They themselves are not responsible for the works necessary to purify liquid wastes before discharge, and dischargers do not have strong incentives to comply with the river authorities' consent conditions, for reasons to be discussed in Chapter 3. When discharges from domestic sources, industry and farms fail to comply with the consent conditions, the river authorities can seldom in practice stop the necessary

discharge of waste water. Nor can they require the discharge of treated effluent to maintain the flow of a river.

29 The Water Resources Act 1963 has been responsible for a great advance in the management of water for the purposes for which it has to be used. But it failed to recognise sufficiently that the quality of water was as important as the quantity. It is now more clearly understood that the national planning of water resources must cover the quality as well as the quantity required. Water may be useless for its intended purposes if it does not reach an acceptable quality, and purified sewage effluent is indubitably an essential part of our water resources.

References

1 Estimates by the Water Resources Board.

2 Second Annual Report of the Water Resources Board. HMSO, London, 1965.

3 Downing, A. L. 'Water for Tomorrow'. Symposium organised by Federazione delle Associazioni Scientifiche e Techniche, Milan, 1968.

Chapter 2 Methods of Sewage Treatment

Extent of main drainage and treatment facilities

30 About 94% of the population of England and Wales is provided with main drainage and although this proportion is higher than in any other country in the world, the position is not as satisfactory as it might seem because the design and performance of a large number of our sewers are defective owing to their age. Many of the older towns in the country are sewered on the combined system in which surface water drains, collecting rain water from paved areas and roofs, are connected to foul sewers carrying domestic and industrial waste waters. To provide relief for the system in times of storm, overflows discharge directly into natural watercourses; the storm sewage from such overflows contains considerable quantities of polluting matter. Some of the sewers were built during the latter part of the last century and are now of inadequate capacity to deal with present-day flows. Consequently some of the storm-sewage overflows operate continuously even in dry weather, discharging crude sewage. Other old sewers leak and cause pollution. Storm overflows are only necessary when the sewerage system is combined or partially separate, and modern practice is to install a separate system for collecting surface water and discharging it direct to natural watercourses. The problem of storm overflows has recently been examined by an expert committee[1] which has concluded that "it would be generally undesirable to adopt a policy which resulted in the construction of new sewerage systems with storm overflows". With this we agree but further consider that where there are overflows, storm sewage should be screened before discharge.

31 Where separate systems are employed we find it is not always realised that local authorities have the right under the Public Health Act 1936 (Section 34) to refuse connection of surface water drains to foul sewers. It is clearly important that local authorities should exercise this power, so that sewers and sewage-treatment works do not become hydraulically overloaded.

32 There are some 5,000 municipal sewage treatment works in England and Wales serving over four-fifths of the population; under 20 per cent of these works serve populations of over 10,000. The works discharge mainly to rivers and, in a few places, to estuaries, the most notable being the Thames which receives vast quantities of effluent (up to 500 mil gal daily in dry weather) from certain of the works of the Greater London Council. The capital value of existing sewage works at present-day (1970) prices is at least £600 million, with a plant life of about 50 years. The treatment provided aims mainly at reducing the oxygen-consuming and sludge-forming polluting constituents in the sewage and is achieved by employing settlement and biological processes as the main stages of treatment.

Sewage and its treatment

33 Sewage is a highly turbid liquid, consisting of a dilute complex mixture of mineral and organic matter in many forms, including: (a) large and small particles of solid matter floating and in suspension, (b) substances in true solution, and (c) extremely finely divided 'colloidal' substances midway between these two categories. It contains living organisms such as bacteria, viruses and protozoa; it is an excellent medium for the development of bacteria, containing several million per millilitre. The solid portion contains paper fibres, corks, soaps, fats, oils, greases, food materials and faeces as well as insoluble mineral matters such as sand and clay. The organic substances present in sewage include carbohydrates, lignins (complex compounds of carbon, hydrogen and oxygen), fats, soaps and synthetic detergents, and proteins. Ammonia and ammonium salts are always present, some derived from the decomposition of urine. The objectionable character of sewage is due mainly to the presence of organic matter which, in the absence of dissolved oxygen, soon putrifies, with the formation of foul-smelling compounds.

34 The nature and strength of sewage is influenced by the type and proportion of industrial (or 'trade') effluents present (including wastes from farms), and by the nature of the carrying water. On average the proportion of industrial effluent in sewage is about half, though it may be considerably higher than this. Generally it is certain of these wastes which present the greatest problem in the treatment of sewage (see Chapter 7).

35 Following the passing of the Rivers Pollution Prevention Act of 1876 (which made it an offence to discharge solid or liquid sewage into an inland watercourse without first rendering it inoffensive), various methods of treating and disposing of sewage were investigated and applied. The early methods included disposal into soakways whereby purification was effected by percolation through the soil; disposal by controlled discharge to large volumes of river water, thus making use of the natural purification capacity of the stream; and by treatment on land after screening and settling of the sewage to reduce matter in suspension. This latter method, which brings about oxidation of the sewage, was at one time extensively used. However, because of the large areas of land required and its high cost, the occurrence of unpleasant smells, the possibility of causing pollution to underground water supplies, and the tendency for the land to become septic necessitating a long rest and treatment with lime, the old sewage farms utilising land treatment have now been superseded in this country by modern sewage treatment works using biological filters or activated sludge. These two processes, which were originally developed in Britain, have since been universally adopted.

36 It is current practice to discharge sewage produced inland to natural watercourses and so convey it to the sea. If pollution of these watercourses is to be avoided so that they can be used for their many requirements, then the organic matter in sewage must be converted to stable substances permitting a reasonably clean water to be discharged. The alternatives to discharging sewage—which is nearly all water—to watercourses, is either to put it on land, or to construct a network of pipelines and pumping installations for conveying it to the sea. For the reasons given in the previous paragraph land disposal has now been discontinued, while the second alternative of pipelines would require very considerable capital expenditure and it would be technically difficult to prevent sewage becoming septic in the long lengths of pipeline involved. As will be seen later in the report, the seaward end of such pipelines would have to be carefully sited, to avoid the possibility of sewage matter being returned to the shore or adversely affecting fisheries. Further, treated sewage effluent makes a very real and vital contribution to the flow of many rivers in this country. We can see no alternative to the present method of treating inland sewage and discharging it to watercourses.

37 Because sewage is disposed of to watercourses it is necessary to control the discharges. Criteria used for assessing the polluting effects of sewage include biochemical oxygen demand (BOD) (which is a measure of organic matter present) and suspended solids. These and the other measurements used are discussed in Appendix 3.

38 The river authorities have the general duty of maintaining or restoring the wholesomeness of rivers, but there is no common standard which they have to require for the effluent discharged to rivers. No standard has been fixed by statute because the character and use of rivers vary so greatly. The river authorities are expected to impose consent conditions with the particular conditions and uses of each river in mind. For example, rivers used for public water supply will in general require effluents of a higher quality than those not so used. We agree that it is not desirable, nor indeed practicable, to have a uniform standard for effluents in this country, and favour the system adopted of relating consent conditions of individual effluents to the particular receiving water.

39 The two standards proposed by the Royal Commission on Sewage Disposal (1898–1915)[2] for no more than 30 mg/l* of suspended solids and 20 mg/l for BOD—a 30:20 effluent—are in general the normal minimum requirements of river authorities for sewage effluents. It may be noted that the Royal Commission in pronouncing these standards envisaged that the effluent would be diluted with eight volumes of clean river water with a BOD of 2 mg/l, and that under these circumstances no problems would result. Nowadays such dilution is not always available and thus to meet the Royal Commission's requirements as regards river water quality, more stringent BOD and suspended solids standards would be required. However, as mentioned in the previous paragraph, effluent standards must be determined having regard to the needs of the particular river and thus should not necessarily be based on, nor limited to, BOD and suspended solids alone. Nevertheless, a 30:20 effluent is reasonably stable and we consider such a quality to be a useful minimum requirement in the majority of situations. In practice we find a 30:20 effluent can generally be achieved readily and consistently by modern methods of sewage treatment properly applied. Constituents other than BOD and suspended solids which are frequently controlled by river authorities include ammonia, heavy metals, cyanides, phenols, dissolved oxygen and others.

Modern methods of treatment

40 The object of modern methods of sewage treatment (see Appendix 4) is to convert the unstable sewage into a stable effluent suitable for discharge to the local watercourse. In this treatment an offensive sludge is produced which must also be disposed of. The whole treatment process must be carried out efficiently and without nuisance or offence. The object of sewage treatment is not, as is sometimes imagined, to produce an effluent of the quality of drinking water nor, necessarily, of the water in the receiving watercourse. From the public health point of view there is a wide gulf between a treated sewage effluent and a potable water, and the former is far from being a liquid safe for drinking.

41 Sewages vary considerably in strength; some are more resistant to purification than others. The volume and strength of sewage are never constant at any sewage works, but vary with the time of day and the activities of the population and of industry. Thus we find it is not possible to have a completely stereotyped system of sewage treatment. Although works conform to some common broad principles, they have to be designed and operated in accordance with the characteristics of the particular sewage to be dealt with.

42 The first process of purification is by settlement under gravity. The preliminary stages (primary treatment) are mainly physical, but, after settlement, the top liquor still contains non-settleable polluting matter. This liquor is therefore subjected to a biological process (secondary treatment), which combines aerobic oxidation of some of the organic matter and ammoniacal compounds present with conversion of the remaining impurities to a settleable form which are settled out and removed. There are two main methods of carrying out this biological stage of treatment, biological (percolating) filters and activated sludge. Both these processes in effect are an artificial intensification and acceleration of the ordinary aerobic processes of natural purification that go on in rivers polluted by limited amounts of organic wastes. In the last few years the use of the activated sludge process has increased and at the present time (1970) the population served by this and by biological filtration are about equal (20–22 million). Where a particularly high standard of effluent is required, a 'polishing' or tertiary stage of treatment is applied after the biological stage.

43 These processes produce quantities of sludge and the treatment and disposal of this is an integral yet independent part of the whole purification scheme. The greater the purification of sewage achieved, the larger is the amount of sludge produced. Several methods are employed in this country for the treatment of sludge, one of the most important being by anaerobic digestion, a process developed in Britain and widely adopted elsewhere; it serves at least half the population at the present time. Before disposal it is customary to reduce the water content of the sludge, even if only to reduce the bulk to be transported; after 'dewatering' the sludge contains about 60 to 80 per cent of water. At a very few works the partially dried sludge is further processed by heat treatment for sale as a fertiliser.

44 We have described the various stages of treatment and methods employed in Appendix 4. The final disposal of sludge is considered in a later section of this chapter. An aerial view of a large modern sewage treatment works employing the activated sludge process and anaerobic digestion, is shown in Plate 1, and a diagrammatic representation of the same works in Diagram 3.

*mg/l—milligrams per litre (equivalent to parts per million).

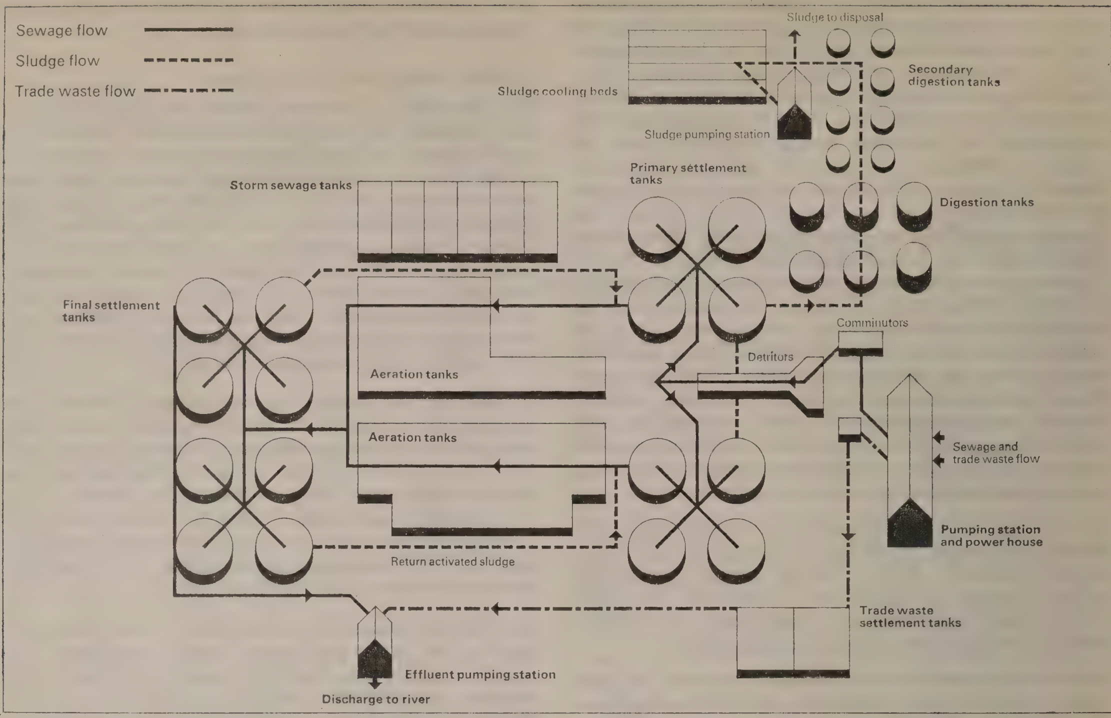

DIAGRAM 3 Layout of a large sewage treatment works (see plate 1 for aerial view of the same works)

Costs of sewage treatment

45 The per capita cost of sewage treatment works tends to decrease with increase in their size. On present-day prices the construction costs to provide treatment to produce a 'normal' 30:20 effluent is about £12 per head of population for large works serving hundreds of thousands of people, to £20 per head for smaller works serving 10,000 persons. Below a population of 10,000 costs rise steeply to £45 per head for a works serving 250 persons, and to possibly to as much as £80 per head for a treatment plant for one dwelling.

46 Detailed figures for expenditure on sewage disposal are not available, but estimates[3] indicate that public expenditure in 1967 was about £35 million per annum on capital equipment and £15 million per annum on running costs. The total expenditure for treating sewage in the municipal sewage treatment works serving some 40 million people in England and Wales, is thus about £50 million per annum, that is, about 25 shillings per person per year or 0·8 pence per person per day. On the basis of an average daily flow at works of 60 gal per person, this average cost corresponds to 1s 3d per 1,000 gallons of sewage treated.

47 This figure of expenditure per capita is, of course, an average based on all existing sewage works. It will be lower at larger works and also at old works where loan charges have been repaid, but will be higher at small works. Also for any new works regardless of size, the cost is likely to be considerably greater than this average figure, because of present-day high construction costs and rates of interest. The cost of treatment of sewage is related to the strength of the sewage; the nature, proportion and treatability of the trade wastes present; the design and type of treatment units used; the degree of treatment required; and the nature of the site and other local conditions. At a works providing full biological treatment to produce a 30:20 standard effluent, the approximate proportions of costs attributable to the various stages of treatment are as follows:

Preliminary treatment (screening and grit removal):	5 per cent;
Sedimentation (primary and secondary):	25 per cent;
Biological treatment:	30 per cent;
Sludge treatment and disposal:	40 per cent.

If the total costs at such works are taken as 100 units then those at a works providing tertiary treatment to achieve a

10:10 (10 mg/l suspended solids and 10 mg/l BOD) standard would be about 115 units; and those at works which, in addition, are required to limit the concentration of ammonia to, say, 10 mgN/l would be around 125 units. On the same basis costs at a sewage works required to provide only partial treatment to reach, for example, an 80:60 standard would be about 85 units[4].

Adequacy of modern methods of sewage treatment

48 Sewage treatment methods have been developed primarily to reduce the sludge-forming and oxygen-consuming organic matter in sewage so that the resulting effluent does not give rise to offensive conditions when discharged to a watercourse. We are satisfied that works employing modern methods of treatment are normally capable of effecting this removal to the extent of about 95 per cent and also, if sufficient capacity is provided, of oxidising ammonia to nitrate (nitrification). By proper control, considerable quantities of toxic materials such as heavy metals and cyanide, can also be removed. The resulting effluent, which satisfies a 30:20 standard, is clear in appearance and may, in the majority of cases, be discharged without adversely affecting the use of the receiving watercourse as a source of potable water supply, as a fishery, or for all other recreational purposes apart from swimming. Such treatment is achieved at the low average cost of about sixpence per person per week (in 1967)—or less than the cost of a Sunday newspaper.

49 In England and Wales the methods used are not only as advanced as anywhere in the world but they are more extensively applied. Full biological treatment plants are provided for four-fifths of the population. With such faciilties high-quality effluents of at least 30:20 standard would be expected and indeed these are often achieved. Notable examples of better than 30:20 effluents are from the works at Luton and at Rye Meads (a regional works which treats sewage from Harlow, Stevenage, Welwyn Garden City and other towns in this part of Essex and Hertforshire). Both works produce, after tertiary treatment, effluents of 10:10 standard or better discharging into the River Lee, which is a source of one-sixth of London's drinking water supply. These very good effluents have been produced consistently for many years from these works, and indicate the adequacy of modern methods of treatment, given sufficient plant capacity, and proper and expert control.

50 These are good examples of what may be achieved, but there are, at the other end of the scale, a great number of works producing poor effluents. Examination by the Water Pollution Research Laboratory of Sewage Works Statistics for 1964–65, compiled by the Institute of Municipal Treasurers and Accountants[5], showed that the yearly average values for suspended solids and BOD in final effluents discharged by nearly 60 per cent of the works were outside the 30:20 consent conditions of the relevant river authority; if individual sample results had been used rather than yearly averages, the proportion would have been far higher. This suggests that on average over 3,000 works in the country are producing effluents inferior to what could reasonably be expected by use of modern treatment methods. Reasons for this most unsatisfactory state of affairs are several, but the main one is lack of adequate available treatment capacity. Although these works have biological treatment, there is just not enough capacity to deal with the pollution load arriving at the works. Consequently, some sewage is inadequately treated while some may by-pass treatment altogether. This situation has arisen because sewage treatment facilities have not been planned in advance to keep pace with housing and industrial development. Indeed there appear to be many cases where the capacity of the sewage works is many years behind current requirements.

51 Only when the overload is so great that the sewage works are in danger of breakdown is development stopped until the capacity for sewage treatment is extended. Sewage treatment facilities, like water supply installations, must be provided in advance of development. This will cost money and more will need to be made available for this very important public authority service. The techniques are available. It is the works themselves which are required.

52 Other reasons for a poor standard of effluent are sewage works which have been inefficiently designed or which are not properly managed or maintained, or which have to receive badly controlled trade effluents. Smaller authorities often lack specialised staff to deal with such problems as trade effluent control, and find it difficult to recruit capable operators. Conditions of work are often unpleasant and consequently it is difficult to keep sewage works properly manned.

53 Because of lack of dilution afforded to effluents in many rivers, together with the need to improve the quality of some rivers to meet present-day demands, it is becoming increasingly necessary for sewage works to produce nitrified effluents* of better than 30:20 standard. Means of achieving nitrified effluents using either the activated-sludge process or biological filtration are now well-understood, while one of the tertiary treatment processes can be selected to reduce BOD and suspended solids. For the benefits achieved, the cost of tertiary treatment is small, adding only about a further 15 per cent to the costs of conventional primary and secondary treatment.

54 Sewage treatment methods however, have their limitations, and it is recognised that sewage effluents will still contain some harmful impurities which may have to be removed if a particularly high grade water is required in a watercourse or if the effluent is required for direct re-use. In this event it would be necessary to select additional specific treatment processes to give a water of the desired quality. Sewage treatment does not completely remove pathogenic bacteria. Although a large proportion is removed, very large numbers may remain in the treated effluent. Disinfection may be achieved by the use of chlorine or ozone at a cost, for large installations, of about 3 pence and 4 pence per 1,000 gallons respectively. We note however that chlorination of sewage effluents can cause considerable problems and consequently it has not found favour in this country for effluent discharged to watercourses[6]. For example, chlorine may combine with chemical compounds in the effluent, such as phenols, giving rise to stable toxic compounds. It may destroy the normal bacterial flora thus upsetting the natural purifying processes; and it is toxic to fish if it reaches river water in more than trace quantities.

55 Sewage effluents also contain residues of organic matter, phosphates, nitrates and high concentrations of other inorganic salts. To remove these constituents further purification is necessary, involving the application of methods relatively unfamiliar in the field of effluent treatment. These advanced treatment processes have been extensively examined in recent years, and include treatment with activated carbon to remove organic matter, and ion-exchange, electrodialysis, or reverse osmosis to reduce the dissolved-salt content. These methods are as yet comparatively expensive costing a few shillings per 1,000 gallons, and

*Effluents in which ammonia has been oxidised to nitrate (see Appendix 3, paragraph 3).

so far have only been used for purifying waters of the quality of well-treated sewage effluents or better. They have not been used for treating sewage and cannot at present be regarded as alternative methods of sewage treatment.

56 Modern sewage treatment processes can be adversely affected by discharge of certain organic chemicals from industrial or domestic premises. New organic chemicals, as yet undiscovered, present a potential danger. Effective trade effluent control can reduce the risks associated with discharges from industrial premises, but there is no legal control over the composition of domestic discharges. The introduction of synthetic detergents on the domestic market in 1949 caused widespread problems at sewage works and in rivers. These detergents were biologically 'hard' being only partially destroyed during the treatment of sewage. A Ministry of Housing and Local Government Committee set up by the Minister in 1953 brought together government, industry and research. Close collaboration of these agencies brought a voluntary solution of the problem through the introduction, in the early nineteen-sixties, of biologically degradable ('soft') detergents, which replaced the original type of material. The case of synthetic detergents emphasises the problems that can arise in the disposal of sewage when new products are introduced for general use, and shows the need to establish in advance what the effects of such products might be on sewage treatment processes and river systems.

57 Kitchen sink waste disposal units (garbage grinders) have not so far been extensively installed in this country, but if they were to become more general they could create serious problems (such as have been experienced in the United States of America) by increasing substantially the quantities of solid matter and of BOD to be dealt with at the sewage treatment works. This additional load could amount to a doubling of the solid matter per person per day and a corresponding increase in BOD of up to 30 per cent[7]. We understand however that there is no difficulty in treating this waste at sewage works if the necessary increased capacity of the various stages is provided[8]. Kitchen garbage grinders also use about $1\frac{1}{2}$ gal of water per person per day amounting to an increase in the domestic sewage flow of about 5 per cent. They can now deal with about 10–15 per cent of the total amount of domestic refuse in an average household and are not likely to reduce refuse collection problems significantly. Their main application would appear to be in blocks of flats, institutions and catering establishments. Where their installation is intended, consideration must be given to the treatment of the waste and it will be necessary to make adequate provision in advance at the sewage works to deal with the additional load resulting from their use. We also note that there appears to be a tendency in hospital design to install waste disposal units for the discharge of disposable bedpans, kitchen, laboratory and theatre wastes to the public sewerage system. It is essential before installing such units that there should be consultation with the sewage disposal authorities.

Disposal of sludge

58 While the liquid part of sewage can be treated satisfactorily, the treatment and disposal of sludge would appear from observations and discussions during our visits and from the evidence submitted to us to be the greatest problem at treatment works today. The traditional method of dewatering by air drying on open beds is far from satisfactory, because of the large areas of land required and the dependence of the process on weather conditions. Mechanical methods appear to offer considerable advantages, while in some cases, polyelectrolytes have been found to be effective aids in hastening dewatering thus enabling larger loadings to be applied to drying beds. The anaerobic digestion process, which is widely employed, still seems to be the most generally satisfactory method available for treating sludge at the larger works.

59 We estimate that of the total sludge produced at inland municipal sewage works in England and Wales serving some 40 million persons, very roughly one-fifth is dumped at sea, two-fifths is applied to agricultural land, and two-fifths is disposed of on land in other ways.

60 Where sea disposal is used (for example, from the works of London and Manchester) liquid sludge, after digestion in the case of these works, is transported in purpose-built vessels and is dumped at a distance from the shore while the ship is still moving, and generally well outside the three-mile limit of territorial waters. There have been no objections from the amenity point of view to this method of disposal. For a large city it is economical and final and is independent of most weather conditions. In view of this, it seems likely that sea disposal of sludge will increase in the future. However, neither the fate of the dumped sludge nor its effect on fauna and flora of the sea, including fisheries, is fully understood. We consider therefore that while this method of disposal may well be presently acceptable, it should be carefully controlled and more research should be undertaken to determine its effects. (See Chapter 5 on Sewage Disposal to the Sea.)

61 A large proportion of sewage sludge produced is disposed of in wet or partially-dried condition by application to agricultural land followed by ploughing in after the sludge has dried out sufficiently. The method makes use of the limited fertilising constituents of the sludge, and risks of transmission of disease by pathogenic organisms are reduced by ploughing the sludge in. Treatment of sludge by anaerobic digestion (see Appendix 4, paragraph 23) largely destroys pathogenic organisms; thus digested sludge has traditionally been disposed of on agricultural land after dewatering on drying beds. During the last ten years or so there has been an increasing trend towards direct disposal by tanker of liquid digested sludge on agricultural land within a radius of about 10 miles of the sewage works. We understand that one large main drainage authority recently has extended the range of this method by using road tankers of about 5,000 gal (23 m^3) capacity to transport sludge a distance of over 40 miles (64 km) to a farm of 800 acres (320 hectares) owned by the authority. The authority has found this method of disposal, properly organised and controlled, to be extremely economical in cost[9]. Over half the available nitrogen in digested sludge is in solution and it is therefore a particularly useful nitrogenous fertiliser, which has been shown to be highly beneficial to a number of crops[10].

62 This method of disposal of liquid digested sludge, containing only about 4 per cent solids, involves the transportation in road tankers of large quantities of water. It also requires that the tankers can gain access to land at all times of the year. This may present problems. Certainly most farmers would be opposed to heavy vehicles, weighing several tons when laden, crossing their land in wet weather because of possible damage to the soil structure. To overcome this difficulty some authorities have installed holding tanks in easily accessible places and use an irrigation system to apply the sludge to the land.

63 Thus some sludges are satisfactorily and economically disposed of on agricultural land with advantage to the farmer. A good deal of the evidence submitted to us in fact

has advocated such a practice, both as a method of disposal and also to use its fertiliser value. It has been suggested that by returning all sludge to land in this way, very substantial savings could be made in the use of artificial fertilisers, which in turn would prevent the interference with, what has been termed, the 'natural nitrogen cycle'. To bring this into perspective it is necessary to compare the total contribution of plant nutrients which sewage sludge might make annually with the consumption of artificial fertilisers.

Sewage sludge as a fertiliser

64 The total dry solids recoverable annually from municipal sewage treatment works in England and Wales is estimated to be about 1 million tons (see Appendix 4, paragraph 21). If sludge from small works in rural areas not on main drainage is included, then the total dry solids recoverable from a contributing population of 43 million is probably around 1·1 million tons a year. An average analysis (on dry matter) of sewage sludge is reported[11] to be as follows:

nitrogen (N)	2·4 per cent
phosphates (P_2O_5)	1·3 per cent
and potash (K_2O)	0·3 per cent.

Using these figures, the quantity of nutrients potentially available from 1·1 million tons of dry sludge solids are about:

26,500 tons N
14,000 tons P_2O_5
and 3,300 tons K_2O

This represents the contribution to agricultural needs if all the recoverable sewage sludge—but not including that discharged without treatment direct to the sea or estuaries—were used on the land.

65 In 1968 the consumption of artificial fertilisers in England and Wales amounted to about 600,000 tons of nitrogen (N) and 350,000 tons of both phosphate (P_2O_5) and potash (K_2O). Estimates predict that by 1980 the corresponding figures will be 900,000 tons of N and 450,000 tons of both P_2O_5 and K_2O. Thus utilisation of all the available sewage sludge represents only about 4·5 per cent of our present annual nitrogen and phosphate consumption and under 1 per cent of the potash consumption. But since about half of the 1·1 million tons of sewage sludge is already applied as manure, the nutrients potentially available in the sludge which is as yet unused, are only about half the percentages indicated above.

66 In addition to the plant nutrients present in sewage sludge, its organic matter forms humus which is a useful soil conditioner. But here again we find it can be shown[12] that the quantity potentially available is only a few per cent of that normally added as a result of good farming practice.

67 Thus the quantities of nutrients and humus-forming matter which would be made available by the use of all the sewage sludge produced in this country, are insignificant compared with those applied each year as artificial fertilisers and contributed by good farming practice. Nevertheless, it seems sensible not to waste any available fertiliser, and we have therefore carefully examined the possibilities of the greater use of sewage sludge on agricultural land. Unfortunately we find the matter is not so straightforward as at first sight it appears.

68 In some areas there is no suitable land and in others sewage sludges may be excessively contaminated with metals or with other toxic materials, making them unsuitable for application as a manure. The National Agricultural Advisory Service is available to give advice on the suitability of sludge for use as manure on different types of soil and has prepared a range of standards for certain heavy metals. Where an authority is proposing to dispose of sludges on agricultural land it should be a prerequisite that the metals content (for example, zinc, copper, nickel and chromium) be determined by prescribed methods and declared. Some sludges derived from certain industrial sewages may contain high levels of pesticides, though in general we understand the amounts involved are less than are normally found in soil.

69 Sewage sludges may contain pathogenic organisms. Although these may be largely or completely destroyed by certain of the treatment processes, where it is proposed to apply sludge to grassland used for grazing, veterinary advice should be sought.

70 For the product to be easily assimilated by the soil it must either be applied in the wet condition, which limits the distance it can be taken because of high freightage costs, or it must be pulverised to a fairly small size, after it has been artificially dried to a very low moisture content. The cost of this process is generally higher than any revenue resulting from the sale of the dried product as a manure.

71 Farmers usually prefer to use artificial fertilisers since they are not only of constant composition and consistency being in a form suitable for assimilation by the soil, but they are completely balanced in respect of the essential nutrients for the particular crop. They also attract a high subsidy payment. We understand that conditions could arise where sewage sludge would qualify for subsidy although on the basis of normal analysis payment would be very small. Sewage sludge is deficient in one of the three essential nutrients, namely potash. It has been suggested that if this deficiency in potash were remedied, then not only would the product be more acceptable to the farmer, but it would attract a reasonable subsidy. This we find is not so, since no subsidy is payable on potash. We are advised, however, that such an addition would mean the product would fall under the scope of the regulations made under the Fertilisers and Feedingstuffs Act 1926, which requires sellers to make declarations and to mark the goods with details of nutrients, and to keep within the tolerances concerned or be liable to prosecution. We believe that whilst some large authorities might be able to meet these requirements, it could be difficult for all authorities to do so consistently.

72 We conclude that the application of sewage sludge to agricultural land is of restricted use. But where it is practicable, it is a good method of disposal and one which should be encouraged, utilising the limited fertilising properties of the sludge. We suggest that local authorities should investigate and embark on more positive marketing methods. We recognise that care is needed to avoid risks to public health, especially when crude undigested or untreated sludges are employed. Properly digested sludges and sludges which have been chemically conditioned with lime or heat treated would however involve virtually no danger when used as fertilisers. Some sludges, digested or otherwise, which are excessively contaminated with toxic materials from industrial wastes, should not be used on agricultural land.

73 For the reasons outlined in the previous paragraphs it is not possible to dispose of all sewage sludge on agricultural land. Large quantities will still have to be disposed of in other ways. Present methods of land disposal include dumping in natural or artificial depressions in the ground called lagoons, where the sludge dries slowly and may cause very objectionable smells; and by trenching, ie, partly filling a number of trenches with sludge and afterwards covering with soil.

74 Problems of sludge disposal are acute in large communities where insufficient land is available, or where the sludge contains excessive toxic materials, or where anaerobic digestion is not feasible. Some authorities are now reaching the stage of having no further means for sludge disposal. The possibilities open to them may be limited to dumping at sea, which depends on the location of the works, or incineration following dewatering, a process recently introduced in this country. Although after this treatment a non-combustible ash still remains for disposal, it is inert and represents only a small proportion of the weight of the partially-dried sludge. The two main methods of incineration are in multiple-hearth and fluidised-bed furnaces, though we understand a new British system is now available at greatly reduced capital cost.

Composting

75 The dual disposal of sewage sludge and household refuse by composting to form an organic manure is carried out at only a few works in this country. The process does not increase the nutrients which each constituent would separately supply and, in fact, in the case of nitrogen, some loss occurs. The process is intended to convert the crude mixed materials into a product more suitable for handling and to render nutrients more available for plant growth. The quantity of sewage sludge which may be composted with household refuse is limited by the need to ensure both aerobic conditions and the correct carbon:nitrogen ratio. Fermentation takes place between the putrescible organic matter in the refuse representing about 13 per cent of the total weight, and the sewage sludge. In actual fact it would appear[12] that the relative amounts of the two waste products are out of balance for complete disposal in this way, and if the whole of the available putrescible matter in household refuse collected in England and Wales were composted, only a comparatively small quantity (about 100,000 tons) of sewage sludge would be required to balance the refuse.

76 The final composted product undoubtedly has a humus-like texture and is inoffensive. But it does contain a proportion of broken glass, and would not, we understand, be acceptable to all farmers and gardeners. It is possible to envisage a situation where an appropriate sewage sludge might, with advantage, be applied as a manure to agricultural land, but the same material after composting with household refuse might be totally unacceptable. Indeed, from one works where dual composting has been carried out, farmers have refused to take the composted material, but have accepted the sewage sludge alone. It is important to note that sludges which are unsuitable as manures because they contain an excess of toxic materials, are unlikely to be made suitable by composting.

77 While we recognise the value of composting, we have serious doubts as to the wisdom of dual composting of sewage sludge and refuse. We found the working conditions of operators of the mechanical composting plant we examined to be unacceptable. Until such time as satisfactory mechanical-handling techniques to remove glass bottles, non-ferrous metals, large objects, and plastics have been developed, the mechanical composting of refuse and sludge cannot be considered satisfactory. In any case, the process could only make a small contribution to the total fertiliser requirements or to the disposal of sludge.

Innovations in sewage treatment

78 The civil engineering works for sewage treatment installations are substantial and are designed and constructed to last for many decades. This practice can lead to problems when changes in operating procedures are required to meet changing circumstances or when extensions are contemplated. For example, it may be advantageous from the treatment point of view to resite units at a sewage works or to employ alternative methods; but with substantial and expensive works such changes cannot readily be effected. We believe there is a need for works to be designed having a shorter life and of cheaper construction than at present, and we suggest that industrialised building techniques should be investigated. Sewage works should not always be built to last indefinitely.

79 Water came into regular use for conveying liquid wastes in this country about 150 years ago. An alternative method, the vacuum system, has been developed in Sweden and used since 1959, and is now in large scale application in different parts of the world. It is based on two main principles:

1. The use of air instead of water for the transport of sewage.
2. Separation of black water (faecal matter and urine—lavatory waste) from grey water (all other household liquid wastes).

The concentrated black water is treated chemically, and the grey water by biological and chemical means. The advantage of the system over the conventional method is the considerable saving in water, which in this country would amount to about 10 gallons per person per day or about 30 per cent of the domestic water supplied. Although such a novel system could be of only limited immediate application in this country because of the high capital investment in sewers and sewage treatment facilities, it is nevertheless worthy of attention (particularly for new development) since it not only reduces the volume of water used and in turn the volume of domestic sewage, but by concentrating the wastes makes them more readily amenable to chemical methods of treatment, permitting the removal of substantial quantities of the nutrients nitrogen and phosphate. A full-scale installation was seen by those of us who visited Sweden.

80 New and improved methods in sewage treatment practice are continually being developed by equipment manufacturers and others. The need to obtain experience of these innovations in full-scale practice is apparent, but there are difficulties in doing this. Consulting engineers and local authorities are not always prepared to advocate the use of new and untried systems, however promising they might seem, while manufacturers cannot afford in many cases to bear the cost of installing and operating expensive plant at a sewage works on the chance of making a sale. Furthermore, under present regulations, untried equipment is subject to a shorter loan repayment period than is proved equipment. Because of this, local authorities are reluctant to use it. If progress in the treatment of sewage and sludge is to be made, it is clear that any promising innovation should be proved under normal operating conditions and that, in achieving this, any element of risk involved should be borne on a national basis. It is therefore suggested that government funds should be made available to underwrite full-scale trials of new equipment, but only after technical approval by the appropriate government agency. It is envisaged that if, after a suitable trial period, the process proves satisfactory, then it should be granted loan sanction and repayment be made in the usual way. If it is not satisfactory then the cost of the trial should be written off by central government. Similarly, there are a number of instances where there is a need to carry out full-scale trials at sewage works of projects which have proved promising on a laboratory scale. Here again it is suggested that government funds should be made available to finance such trials. It is essential that

results of any such work so carried out should be widely publicised.

Recommendations

81 Adequate modern sewage treatment facilities must always be provided in advance of demand, just as water supply installations are provided. To ensure this, continuous liaison between planning authorities and sewage authorities is required and future needs must be anticipated. (Paragraphs 50 and 51).

82 Public investment in sewerage and sewage treatment plant must be increased substantially to enable adequate facilities to be provided at works for the production of satisfactory effluent. Modern sewage treatment methods are capable of achieving satisfactory effluents if of adequate capacity and properly operated. (Paragraphs 48–51).

83 If the installation of kitchen sink waste disposal units is to become more widespread the capacity of the sewage treatment works must be correspondingly increased to deal with the resultant additional load. (Paragraph 57).

84 Government funds should be made available to (1) finance full-scale trials at sewage works of proven laboratory-scale projects, and (2) underwrite the costs of full-scale plants at sewage works involving newly-developed processes; and the results of such work should be well publicised. (Paragraph 80).

85 Changes in conventional methods of construction of sewage treatment plants are needed, permitting greater flexibility and production of shorter-life plants to meet rapidly changing requirements. The use of industrialised building techniques should be investigated. (Paragraph 78).

86 Wherever possible encouragement should be given to the application to agricultural land of digested sludges and certain chemically or heat-treated sludges not excessively contaminated with toxic materials, both as a means of disposal and to utilise the limited fertilising value of the sludge. Where the land is to be used for grazing, veterinary advice should be sought. (Paragraphs 67-72).

87 Where sewage sludges are applied to agricultural land the content of certain toxic metals (for example, zinc, copper, nickel and chromium) should be declared to the user. (Paragraph 68).

88 Sewerage in new development should separate foul sewage and surface waters. Where there are combined systems, discharges of unscreened storm sewage should be prohibited. (Paragraph 30).

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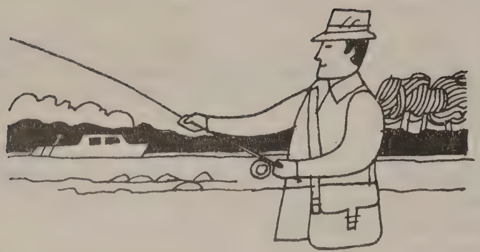
Chapter 3 Sewage disposal to rivers and canals



Rivers, and the extent of pollution

89 Rivers are a cherished part of our landscape. Gathering the rain from the sky they take it to the sea. They attract large numbers of people for recreation on their banks and on their waters. They supply most of our drinking water and the water used by industry and agriculture. They take away most of our industrial and sewage effluent and the waste heat from industrial processes. Typical uses of a river are illustrated in Diagram 4, page 15.

90 Natural river water can be crystal clear or turbid; odourless or with an earthy smell; fit, or too contaminated for public water supply after conventional treatment. In their natural state rivers support plants, fish and animals which live together in a more or less stable ecological system.

91 Slight pollution by domestic sewage or some kinds of industrial waste usually does little harm to river water and its living creatures, as dilution, the oxygen in the river, and the normal bacteria and other organisms can render the pollution harmless. But the self-purifying properties of rivers are limited. Water abstraction for industry, agriculture and public supply has reduced the volume of clean water in many rivers while sewage effluent discharges have increased. For example, in dry weather some reaches of the Irwell, Tame, Rother, Mersey and Don, and Shakespeare's Avon at Stratford are normally at least half treated sewage effluent.

92 Some stretches of river which carry effluents from industrial and large urban areas are grossly polluted (see Plate 2). An example which we have seen on one of our visits is the River Tame which carries effluents from the Birmingham area. An analysis of its water has shown that it is more contaminated than a normal sewage effluent. A close look reveals ubiquitous shreds of sewage fungus and particles of miscellaneous obnoxious matter. After heavy rain, the river carries down a tremendous load of garbage, from plastic bags to prams, which remain by the slimy banks after the storm has subsided.

93 Despite the recognition by Parliament that river pollution should be controlled there is no national assessment of the quality of river water which would show the current extent of pollution and the effects of statutory powers of control. A River Pollution Survey is however now (1969–70) being undertaken by the Ministry of Housing and Local Government, and the Welsh Office, in co-operation with the river authorities, the Confederation of British Industry and the local sewage disposal authorities. The most comprehensive information previously available relates to 1958, when the Ministry completed an informal survey. This survey showed (Table 1) that, while most lengths of our rivers were unpolluted, a considerable length of rivers in our most densely populated areas was grossly polluted.

Table 1. Degree of pollution of rivers in England and Wales 1958
[From an informal survey, by Ministry of Housing and Local Government Engineering Inspectorate, of non-tidal rivers with a dry weather flow of at least one million gallons a day].

Class	Description of river	Miles	% of Total
1	Unpolluted or recovered from pollution	14,603	73
2	Doubtful and needing improvement	2,865	15
3	Poor and urgently needing improvement	1,279	6
4	Grossly polluted	1,278	6

The criteria used for this classification are set out below.

Class 1 rivers

94 a. Receiving no significant polluting discharges.
b. BOD less than 3 mg/l.
c. Well-oxygenated.
d. Indistinguishable biologically from those in the area known to be quite unpolluted, even though the BOD may be somewhat greater than 3 mg/l.

These rivers will be fit for normal uses although it may not be safe to bathe in them.

Class 2 rivers

95 a. Known to have received significant polluting discharges which cannot be proved either to affect fish or to have been removed by natural processes.

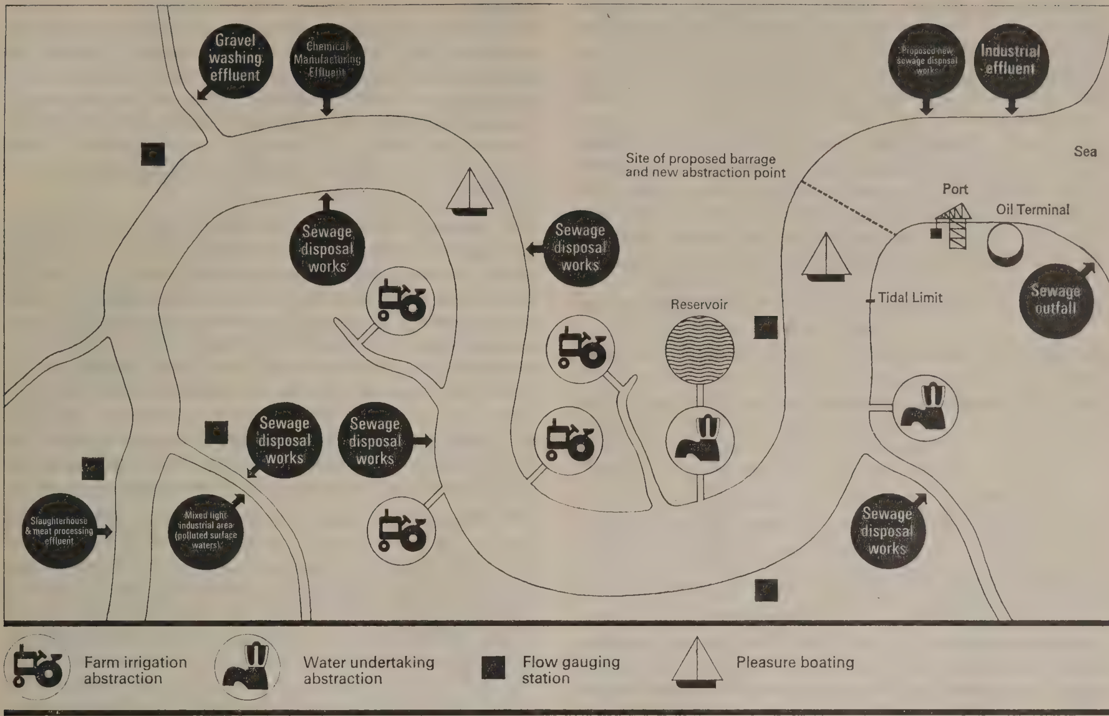


DIAGRAM 4 Typical uses of a river

b. Not in class 1 by BOD standards.

c. Which have a substantially reduced oxygen content at normal dry summer flows or at other regular times.

d. Known to have received turbid discharges which have had an appreciable effect on the composition of the water or character of the bed but have had no great effect on the biology of the water.

These rivers may support game fish (eg salmon and trout) as well as coarse fish and be fit as a source of public water supply.

Class 3 rivers

96 a. Containing substances which are suspected of being actively toxic at times.

b. Not in class 4 on BOD standards.

c. Having a dissolved oxygen saturation, for considerable periods, below 50 per cent.

d. Changed in character by discharge of solids in suspension but not justifying placement in class 4.

These rivers may support coarse fish but they are not fit for use for public water supply or high grade industrial use and may not be fit for irrigation or for supplying cooling water for industry.

Class 4 rivers

97 a. Known to be incapable of supporting fish life.

b. Having a BOD of 12 mg/l or more under average conditions.

c. All which are completely deoxygenated at any time, apart from times of exceptional drought.

d. Rivers which are the source of offensive smells or which have an offensive appearance, apart from the presence of detergent foam.

These rivers cannot be used for public water supply, by agriculture for irrigation or by industry for process water. They are not pleasant for people who live or work by them or who use them for recreation.

Canals, and the extent of pollution

98 Although canals are not used as much commercially

as they were, pleasure cruising on them is increasingly popular, and they provide at least 900 miles of good fishing water, often within easy reach of towns where other fishing is scarce. Their water is sometimes used for industry and agriculture. The causes and consequences of pollution are similar for both rivers and canals. As the water in canals is generally more sluggish than the water in rivers, canal water is more prone to pollution, as the 1958 survey results show (Table 2). The canals cutting through the most densely populated areas again show the worst pollution. The data available on canals was less detailed than for rivers, so the figures are broad estimates.

Table 2. Degree of pollution of canals in England and Wales 1958

[Ministry of Housing and Local Government informal survey.]

Class	Condition	Miles	% of Total
1	Clean	900	58
2	Doubtful	380	25
3	Poor	130	9
4	Grossly polluted	120	8

99 River authorities exercise their pollution prevention powers for canals as well as rivers. The British Waterways Board, the owner of canals, also enters into agreements with abstractors of canal water covering the condition of the effluents they discharge.

100 The British Waterways Board has been able to take effective action to terminate discharge agreements when conditions have not been complied with, but, as the figures show, pollution is nevertheless more prevalent than in rivers. There are many local problems in the Board's canals, such as industrial effluents from old-established concentrations of industry; brine; septic-tank overflows; and farm sewage brought down by streams. The British Waterways Board however reports a gradual improvement in the quality of effluent discharged by local sewage disposal authorities and industrialists.

Effects of pollution on recreational use of rivers and canals

101 As more people own cars and enjoy longer hours of leisure, there has recently been a great increase in outdoor recreation. Its most popular form is taking a trip in the car with the family to some place of interest, which is often by a river or stretch of water. Angling has increased by 50% between 1954 and 1964. In 1966 there were estimated to be 3 million anglers, more people than participated in any other sport except swimming. Boating is thought to have increased twelve-fold between 1952 and 1962 and the numbers of boatmen was estimated to be 700,000 in 1966 (50,000 less than golfers but 50,000 more than amateur football players). In 1965 there were 5 boats to every 1,000 people. There were in 1966 about 45,000 rowers and 35,000 canoers. Water skiers have increased from a handful in 1955 to over 75,000 in 1966.[1]

102 There are about 209,000 acres (85,000 hectares) of inland non-tidal waters in England and Wales. Rivers and canals are just over half of this area; reservoirs, lakes and ponds make up the rest. Town dwellers visit most often water within 40 miles of the conurbations[1]; some of the most polluted stretches of rivers are found within that radius.

Angling

103 Angling is the sport most obviously affected by pollution. Pollution affects fishing, either by harming the fish directly, or indirectly through its food. Pollution due to heavy organic loads reduces the variety of food organisms available while chemical pollution tends to reduce both the number and variety of food organisms. Adjacent to heavy pollution the variety and number of fish are consequently reduced.

104 Between the limits of a thriving mixed population of fish and the absence of all fish life, there is a wide range of effects, including reduced growth rates, greater susceptibility to disease and alteration of behaviour patterns, which may be caused by various degrees and types of pollution. All such effects are harmful to fishing as a recreation. In many streams and rivers in industrial areas no fish can live. There are none for example in reaches of the Weaver in Cheshire, the Irwell, the Mersey in Lancashire, the Worcestershire Stour, the Warwickshire Tame, and the Don and the Rother in Yorkshire. The quality of fishing is impaired by polluting discharges in many other rivers.

105 Stretches of some rivers have been reclaimed for fishing by adequate treatment of domestic sewage and industrial effluent. For instance, as a result of a new sewage works at Derby which treats industrial effluent as well as domestic sewage, the River Derwent below Derby no longer suffers from sewage fungus and is now a fishery. It is being developed as a source of drinking water. Since the 1950's in the country as a whole, it seems the tide of pollution has been reduced, in spite of the increased volume of effluents entering the rivers. Many miles of river have been regained as fisheries and improved stocks and larger catches testify to greater vigilance and more thorough treatment of liquid wastes.

106 Anglers are, in practice, unpaid watchmen for the pollution control officer of a river authority, as they are often the first people to detect toxic pollution, by the obvious evidence of dying or dead fish, and the less obvious evidence of steadily declining catches. The abundance of fish is usually a good indication of the condition of the water. A fish toxicity test, carried out under controlled laboratory conditions according to a standardised procedure, has been developed, and can be used by river authorities when normal methods of analysis are inadequate[2].

Bathing in rivers and canals

107 It is not known to what extent rivers are used for bathing, but it is obviously popular in pleasant reaches of rivers. Many of the rivers where people bathe contain sewage effluent, so we have carefully considered whether there is a risk to health when bathing in such rivers.

108 Hazards to public health may arise from bathing, paddling, from accidental immersion and from the recreational use of river banks where residues from river water have been deposited. The problem is one of transmission of communicable disease, and in contrast to the use of rivers as sources for drinking water, chemical pollution is unlikely to offer a hazard. It is obviously hard to generalise on the risk, for the degree of pollution will differ widely in pure mountain streams, where the only contamination arises from the wild life of the area, from the grossly polluted rivers and canals of urban areas. In any one locality it is not possible to measure the degree of risk. In some cases patients suffering from mild infections after bathing may not consult their doctors; in others the possibility of an association with the river is not realized; and in yet others it is not possible to prove an association. Communicable

diseases are normally passed either as a result of the infection of persons in the close environment of a patient or carrier of the condition, or as a result of the contamination of some article of food. Against this background of disease in a community it is usually hard to identify an occasional case which might be contracted from river or other inland waters.

109 Occasionally in the past cases have been reported of enteric fever resulting from the recreational use of inland waters. These are usually found by the upper reaches of rivers where it is easier to identify the same type of organism in the patient and in the water, and to trace the source of pollution. Such cases appear to be more frequently associated with contamination of the banks of a stream than with actual bathing. Similarly polluted streams have in the past given rise also to milk-borne outbreaks of disease through contamination of cow's udders and of dairy utensils.

110 In the higher reaches of rivers the apparent purity of the water may be deceptive. A carrier of enteric disease could contaminate a small stream as a result of a discharge of crude sewage, a septic tank effluent, or a treated effluent from a small sewage works.

111 Possible association of communicable disease with pollution in the lower reaches of rivers is more difficult to demonstrate. In Chapter 5 (dealing with sewage disposal to the sea) the importance of the dilution factor will be described. Illness will usually occur only if the numbers of any specific type of pathogenic organism ingested are very considerable, and as a result, the risk associated with sea bathing is minimal. With river bathing the problem is different. In a river the proportion of crude or untreated sewage is probably relatively small, though local pockets of high pollution near to points of discharge may exist. Rivers, however, contain considerable quantities of treated effluent, and sometimes part of their length may even be wholly sewage effluent. It is known that conventional sewage works treatment, while producing an effluent which is normally chemically satisfactory, is less effective in dealing with pathogenic organisms. Although more than 90 per cent may be removed, there may still be many thousands of faecal bacteria remaining in every millilitre of treated sewage effluent. They will contain disease-producing germs and viruses if there is infection in the local population.

112 A river receiving effluent from a number of large treatment works may therefore contain numbers of pathogenic organisms and the degree of dilution in the limited amount of river water available may not be large. It is difficult therefore to weigh the chances of infection from such water. The risks are probably greatest from accidental immersion when the proportion of water ingested may be higher than when persons are swimming or paddling. In most circumstances the risk is probably very low as may be judged by the numbers of persons, and in some cases communities such as schools, who have bathed in such waters in the past without apparent ill effect. Nevertheless it is customary for public health authorities to advise against bathing in these waters, and public bathing places or school bathing stations on such rivers have usually been closed. The decision is perhaps in part an aesthetic one, since Medical Officers of Health and other people knowledgeable about the risks, while advising against swimming, will agree to children paddling and playing in the river although these children also may swallow small quantities of polluted water.

113 Canal water in industrial areas is often highly polluted (partly on account of the slow rate of flow) and may often be highly offensive. Cases of spirochaetal jaundice, a rare disease whose causative organism is to be found in rat's urine, occasionally result from immersion (usually accidental) in heavily polluted canal waters or in the waters of slow moving polluted rivers in urban areas.

Other recreation on rivers and canals

114 The most popular pastime of bringing the family car to a riverside to walk, picnic and view the scene is not so obviously affected by pollution unless it is visible or can be smelt. In some places overt pollution certainly spoils this kind of enjoyment, as in an example quoted in the evidence of the National Federation of Women's Institutes, describing how raw sewage from an overloaded works flowed into a mill pool which was "a favourite picnic place for villagers and visitors alike". Families very often like to combine car trips with a little fishing, paddling or bathing which can be impossible, or dangerous to health, in heavily polluted rivers. Rivers in industrial areas are usually easily accessible to large numbers of people, but their amenity value may be totally destroyed by pollution.

115 Although boating is apparently quite popular on polluted rivers because they are accessible, the dirty water, the smell and the sewage fungus and other objectionable matter in the water or on the banks detract from pleasure. River authorities report increasing pressure from the public for higher standards in water quality for the sake of amenity. The amenity value of rivers is already recognised by the provisions in the Water Resources Act 1963 for maintaining a minimum acceptable flow in rivers. It seems logical to set also a minimum acceptable standard for water quality, as, however adequate the flow of the river, it cannot be enjoyed if it is laden with shreds of sewage fungus and is depositing filth by its banks.

116 Special efforts to improve the environment in river valleys in order to create new centres for recreation, or for the pleasure of the local residents, should include any improvement necessary to the main attraction in a river valley—the river itself. In the Greater London Council Development Plan for instance, the Cray Valley is listed as an area of special character, because of the beauty of the countryside. The valleys of the Colne, Crane, Lee, Roding, Ravensbourne, Wandle and Hogsmill, are listed as areas of opportunity for environmental treatment. The Lee Valley Regional Park is being developed as a centre for recreation, particularly for water sports. A group of local authorities concerned is now drawing up a plan for the use of the Mersey Valley for recreation and for improving its amenities.

Waste from boats

117 The growing use of rivers and canals for pleasure cruising can itself impair the pleasure, if boats discharge their lavatory and kitchen waste straight into the water. Even if the overall pollution from discharges from boats does not affect the quality of the river water as a whole, this practice is aesthetically objectionable and can cause obnoxious conditions where boats are concentrated, as in marinas, or on popular stretches of water. Discharges from boats in such places could also cause a risk to health because people (particularly children) might be in direct contact with faecal matter in the water surrounding their boats.

118 River authorities can make byelaws under Section 5 of the Rivers (Prevention of Pollution) Act 1951 to prohibit discharges from boats. No such byelaws are yet in force (1970), although the East Suffolk and Norfolk River Authority's byelaws for the Norfolk Broads have been confirmed by the Ministers of Housing and Local Government, and of Agriculture, Fisheries and Food, and will be

effective from 1 January 1973. The Thames Conservancy has for many years prohibited discharges from boats under the navigation powers which it possesses as a combined river and navigation authority of non-tidal waters. It can enforce the prohibition of discharges, as it inspects boats for other purposes. As a navigation authority, the Thames Conservancy can also erect disposal stations, while normally a river authority has to rely on boat yards or local authorities to make arrangements for disposal of the contents of chemical closets.

119 There are places where evidence shows that discharges from boats are creating a disgusting nuisance, and we consider that all rivers where boating is popular should be protected from this pollution. The practice of discharging raw sewage to watercourses should no longer be acceptable in this country. Eventually no boats anywhere should have lavatories which flush directly into any inland waters. On canals and lakes where the water is not flowing freely the practice is even more objectionable. Arrangements for the disposal of the contents of chemical closets will have to be made by the riparian local authorities and the boat yard owners.

120 The Ministry of Transport, on behalf of the British Waterways Board, have stated that an increasing number of canal craft are installing chemical sanitation. In 1968 the Board installed nine new chemical disposal points, most of which also included lavatories.

121 On the rivers, the cost of providing disposal points and lavatories should fall mainly on boat users, rather than on the local residents through their rates. We consider that, to encourage the use of these facilities, private boat owners should be able to pay an annual fee rather than pay for each discharge separately, while boat hirers could meet the costs of disposal units through their hiring charges. Local authorities and boat hiring firms together with associations of private boat owners should work out a plan for the sanitary facilities needed on a river.

Effects of pollution on use of rivers for water supply

122 About two thirds of the water put into public supply in this country is taken from rivers and lakes. Although it is preferable to obtain these supplies from the upper part of the catchment where the water is generally unpolluted, these clean sources are becoming increasingly difficult to find and to exploit economically. As demand has grown, many water undertakers have had to take their additional supplies from stretches of rivers in the lower reaches where the water often contains appreciable proportions of sewage effluents. Sometimes the location of a particular undertaking leaves little choice but to use such sources.

123 The Metropolitan Water Board and its predecessors, for example, have for centuries taken the bulk of their supplies from the Rivers Thames and Lee, both of which contain substantial quantities of treated sewage and industrial effluents. With increasing discharges over the years, the dilution afforded some of these effluents has become inadequate, and in order to safeguard sources, higher effluent standards have had to be imposed. Such a source is the Board's New River intake on the River Lee which is used to supply 600,000 people in north and central London. The River Lee rises just north of Luton and ends after a course of 56 miles by joining the tidal Thames. For more than 20 miles downstream of Luton the river water in dry weather is composed almost entirely of sewage effluents from Luton, Harpenden, Wheathampstead and Hatfield. That from Luton in particular, contains substantial quantities of treated industrial wastes. The river Lee is joined by three tributaries carrying clean water just before it reaches the intake near Ware. At this point sewage and industrial effluents make up about 50 per cent of the normal daily flow of the river. It is only the maintenance of the quality in the upper reaches by the enforcement of very strict standards for sewage effluents, together with the natural self-purifying capacity of the river, that make this river suitable as a source of raw water.

124 The tendency towards the increasing use for public supply of water taken from the more heavily polluted lower reaches of rivers is a cause for concern, because of the nature of the polluting matter which may be present.

125 As we have seen in Chapter 2, sewage treatment effects a large percentage reduction of solid material and of soluble organic carbonaceous matter originally present in the crude sewage. But the treated effluent still contains large numbers of bacteria and viruses of intestinal origin, some of which may be pathogenic. These organisms will be effectively destroyed and the residual solid matter removed by normal processes of water treatment. But the remaining soluble organic matter which is not amenable to biological oxidation in sewage treatment processes or in the river, is not completely removed in the treatment of water. Therefore, if the river water contains treated sewage residues, the water passed into supply after treatment will contain traces of residual organic matter. Analysis of the water by standard determinations will give an indication of the total concentrations of these residues present, but it will not help in the identification of the compounds present. More refined methods of analysis are continually being developed, but at the present time, and in the foreseeable future, it will not be possible to identify all the large varieties of complex organic substances which may be present.

126 The public have been consuming treated river-derived water containing traces of organic matter for very many years. There is no analytical evidence of any increase in the organic matter content of such supplies, though it may be changing in character. Although many of the carbon residues derived from domestic sewage and from some industrial effluents may well be harmless, the water might also contain 'hard' (biologically resistant) organic residues resulting from new materials introduced on the domestic market as well as from certain industrial processes. These 'hard' residues, which may be undesirable, would be measured collectively as total carbon along with the other 'safe' residues. It is possible to reduce the carbon residues considerably by additional and expensive methods of water treatment.

127 Because of the varying nature of individual carbon compounds which make up the total organic residue it is not possible to lay down any standards for carbon content as measured by organic carbon, chemical oxygen demand or permanganate value. In the context of water supply, BOD determination is of little value since it is merely a measure of some of the residual organic matter and possibly some of the unoxidised ammonia. Each situation must be considered separately, bearing in mind the types of industry contributing effluents. Many industries, particularly chemical production industries, while knowing the identity of what they manufacture, may not be so well informed about what they throw away. Although the chemical identity of such wastes may be impossible to determine, it is essential that their biological properties be established to ensure that they do not inhibit subsequent treatment.

128 Where river water is to be used as a source of potable water, we consider it imperative that there should be a close

control of industrial effluents produced in the river catchment, whether these effluents are discharged to the local authority sewers or directly to the river after treatment. Also, the expansion of existing industries or the siting of any new industrial premises producing effluents likely to contain synthetic organic chemicals (such as those engaged in the manufacture of fine chemicals, pharmaceuticals or agricultural chemicals) must be carefully controlled. Effluents from these industries are always liable to contain quantities of materials, sometimes of unknown composition, which are stable and biologically potent at very low concentrations.

129 No matter what reasonable precautions are taken, there is always the risk of accidental discharge either from industrial premises or from local authority sewage treatment works in a highly urbanised area. The provision of adequate storage reservoirs for abstracted river water is advisable, since they provide a double safeguard, enabling abstraction to be halted for a period, and ensuring dilution of any polluted water which may enter the reservoirs.

130 In addition to organic residues, there are other constituents of polluted river water which must be controlled where the river is to be used as a source of potable supply. For example, ammonia is objectionable, but may be removed by operating sewage treatment plants so as to achieve full nitrification. The amount of nitrate (the oxidation product of ammonia) must also be carefully controlled. From a health point of view, the nitrate level is under constant observation by the appropriate authorities and government departments. It should be pointed out that, in a polluted river, nitrate is reduced to elemental nitrogen if the dissolved oxygen content of the water falls below about 10 per cent of saturation.

131 Nitrate nitrogen in rivers is derived mainly from sewage effluents, from run-off from fertilised agricultural land and from natural mineral sources. A study of the Great Ouse[8] revealed that sewage effluents contributed only one-sixth of the mass flow of nitrogen, the remainder coming presumably from agricultural land. This may arise from decaying vegetation (crop residues and plant roots), animal excreta or inorganic fertilisers. During recent years, the quantity of fertiliser applied to arable land has increased considerably and, in consequence, drainage from intensively farmed arable land in England and Wales may now contain on average as much as 10 mgN/l of nitrate, and considerably more at times of heavy rainfall in spring.

132 Reasons for the loss of nitrate from fertilisers are, firstly, because the nitrogen fertilisers at present used are not efficiently taken up by crops; and secondly, because unused nitrate is not retained in the soil. People engaged in agriculture are naturally concerned about the loss of nitrogen fertilisers, and work is being carried out on new application techniques, and also to find alternative nitrogen compounds which are used more efficiently by crops. We are of the opinion that this work should be given priority, not only to economise in fertiliser, but also to reduce the mineralisation of surface and underground waters. In considering the discharge of nitrate from agricultural land, the contribution from animal excreta and decaying vegetation must not be overlooked. We have evidence that some supplies of water for drinking contained several milligrams per litre of nitrate many years ago, well before the intensive and widespread use of inorganic fertilisers.

133 Evidence obtained in the study of the Great Ouse, referred to above, suggests that drainage from fertilised land contributes not only the bulk of nitrate to the mineralisation of polluted river waters, but most of the potash, silicate, chloride and sulphate as well. On the other hand rivers receiving large quantities of sewage and industrial effluents will obtain the greater proportion of their nitrate and other inorganic chemicals from these effluents. The phosphate load in such waters is also derived mainly from sewage effluents; about half of the phosphate comes from use of synthetic detergent preparations. In general the present level of each of these constituents in river water does not limit its use as a source of domestic supply.

134 In recent years problems have been caused as a result of the enrichment of waters by phosphates, nitrogen and potash. This progressive enrichment, known as eutrophication, is a natural process in the ageing of lakes and impounded waters, but one which is greatly accelerated by discharges of domestic and industrial wastes, and from agricultural land drainage. In some countries, enrichment of lakes and reservoirs has become so great that very large masses of algae and aquatic plants develop each year. When such waters are used as a source of potable supply, problems of taste and odour sometimes arise. Loss of efficiency of filters used for water treatment, through accelerated clogging, also occurs. Algal blooms and aquatic plants render reservoirs unsightly and undesirable for recreation, while under extreme conditions death of fish may occur, through a lack of dissolved oxygen, following decay of the vegetation.

135 There is evidence that some rivers in Britain with high nutrient levels are occasionally affected by excessive algal growth during years of exceptional sunshine, though in general it appears that eutrophication is unlikely to create problems in the free flowing rivers in this country. But difficulties could arise when such rivers discharge into lakes or impoundments, eg behind barrages, or when water is pumped from these rivers into reservoirs. We understand that the Metropolitan Water Board has been faced with these problems for many years and has had to apply various expedients of reservoir construction and reservoir management to combat the effects. The situation therefore needs to be kept under close review.

136 Nitrates and phosphates are generally considered to be the major nutrients which accelerate eutrophication, though some trace elements and organic substances may also play a part. In addition, physical environmental factors such as light intensity, temperature, and size and shape of the lake basin, are important. Attempts to control eutrophication are being made in the United States and in Sweden by removing nitrates and phosphates from sewage effluents. The methods employed do not, we understand, reduce these nutrients to levels that would avoid algal growths, although their removal may slow down the rate of eutrophication. There are sources of nutrients other than sewage effluents.

137 Before the implications of present trends and the possible need for remedial measures can be fully assessed more information is required about conditions giving rise to growths of aquatic plants and algae. We are pleased to note that the Natural Environment Research Council, in collaboration with the Water Pollution Research Laboratory and other organisations, has this study in hand.

138 We conclude that, while the use of polluted rivers as a source of raw water has obvious economic advantages in areas where alternative supplies are not readily available, there may be potential dangers to public health arising from long-term ingestion of trace organic residues from some

discharges, particularly those from certain chemical industries. Close control of all discharges and enforcement of strict standards for sewage and industrial effluents is essential and increased vigilance will be required to protect sources of public water supplies from harmful pollutants.

139 During our deliberations the importance of water quality in water supply has become very evident. We note with pleasure that the Ministry of Housing and Local Government has recently set up a steering committee to promote and co-ordinate studies in water quality.

140 In addition to river water abstracted by water undertakings, a considerably larger quantity is taken privately by agriculture and by industry. Agricultural demands have markedly increased since 1945, mainly due to an extension of irrigation, which has been carried out for many years to increase the yield of market garden crops. Nearly all this water is applied as a spray, and by 1961 enough irrigation equipment existed to water over 130,000 acres (52,000 hectares) of crops. This increased by an average of 15,000 acres (6,000 hectares) per annum during 1961–1967. Future expansion is likely to be slower than in past years, since with the implementation of the 1963 Water Resources Act farmers are now required to pay for the water they abstract. It is important to note that little, if any, of the water so used is returned to the water system for subsequent re-use.

141 Two factors are of importance when water is used for irrigation. First is the obvious one of public health dangers arising from the irrigation of crops, intended to be eaten raw, with polluted river water. We should mention that this matter is the responsibility of the local authority, and not of the river authority. In general, we understand there is no danger to health except possibly where the river contains very substantial quantities of sewage effluent. Even in this event, there is reason to believe that the water would be acceptable for use in this way after lagoon storage for several weeks[4]. The second quality factor is that of the mineral content of water in relation to plant growth and soil structure. We understand information on this subject is sparse, but that which is available suggests that the presence of toxic metals, zinc, boron (derived mainly from synthetic detergent preparations) and high chloride concentrations are matters of concern in relation to plant growth, while the concentration of sodium ions in water may affect soil structure. With the increasing re-use of river waters, this could become a serious problem, and we suggest that work should be put in hand to examine these effects.

142 By far the largest proportion of water abstracted from rivers by industry is used for low-grade purposes, such as cooling at power stations and quenching in steel manufacture. For some other industrial purposes, polluted river water may contain harmful impurities giving rise to problems of corrosion, slime-growth and excessive foaming. In general, apart from suspended solids and organic matter, the most significant constituents are total dissolved salts, chlorides and detergents. If the content of these is excessive, then it is necessary to select specific treatment processes to give waters of the required quality. With modern methods of water treatment it is technically possible to produce a pure water, even from the most polluted of waters, the cost of the treatment depending among other things on the quality of water desired, as well as on the concentration of the pollutants originally present. Thus pollution of river water may not prevent its use for industry, but it clearly imposes an additional cost on production. Chlorination is usually the minimum treatment, chemical coagulation and sand filtration being the next refinement, and demineralisation the final process for yielding the highest grade water.

143 The Water Pollution Research Laboratory has demonstrated that a clear sterile water suitable for many industrial purposes can be produced directly from sewage effluents at a cost of about 1s per 1,000 gallons (4,500 l) by employing standard water-treatment processes of coagulation, sedimentation, filtration and chlorination[5]. Also, in collaboration with the Metropolitan Water Board and others, it has shown[6] that a water of similar quality can be obtained by treatment based on the use of ozone and microstraining. This process has the advantage over coagulation methods of not increasing the mineral content of the water.

The causes of river and canal pollution

144 Evidence cited in Chapter 2 (paragraph 50) showed that about 60% of local authorities' sewage effluents fail to reach the standard recommended by the Royal Commission on Sewage Disposal for no more than 30 mg/l of suspended solids and 20 mg/l for biochemical oxygen demand (BOD).

145 The figures given in the table below illustrate the quality of effluent of dischargers regularly discharging more than 1,000 gallons (4,500 l) a day, in the area of one river authority.

Table 3. Classification of individual discharges of trade and sewage effluent to non-tidal waters.
(From Mersey and Weaver River Authority Annual Report 1969)

Dischargers	Usually satisfactory	Tending to be borderline	Usually unsatisfactory	Unusually bad	Total
Sewage works	111	66	70	8	255
Trade premises	39	35	92	12	178
Total	150	101	162	20	433

Sewage effluents below standard

146 The reasons why the effluents from sewage treatment works fail to conform to the river authority's standards have been described in paragraphs 30 and 50–52. The principal cause is overloading, of the treatment works or of the sewers.

147 By virtue of the Rivers (Prevention of Pollution) Acts 1951 and 1961, to "maintain or restore the wholesomeness of rivers", river authorities have the power to prosecute dischargers for breach of the conditions of consent controlling a discharge, but they usually try to proceed by persuasion rather than by prosecution. If consent conditions are not complied with because sewage treatment works are overloaded, prosecution cannot in any case remove the overload. River authorities are reluctant to put legal pressure on defaulting local authorities, which are public bodies like themselves. A majority of river authority members are appointed by county councils and county boroughs and the remainder of the members are nominated to represent various interests by the Ministers of Housing and Local Government, or the Secretary of State for Wales and by the Minister of Agriculture, Fisheries and Food. Few local authorities have been prosecuted because the discharges from their sewage treatment works failed to comply with the river authorities' consent conditions.

148 Limitation of government expenditure due to recurrent financial crises has restrained expenditure on sewerage and sewage disposal, although this expenditure has been rising considerably and has doubled in real terms during the last 10 years. In 1968–9 it was about £98 million a year on maintenance and about £100 million on capital account, equal to about 0·5% of the gross national product. Local sewage disposal authorities who have been reluctant to undertake expenditure on sewage treatment, as there are no 'votes in sewage', have been able to refrain from necessary extensions to sewage treatment works. The cost of sewage treatment works built in advance of development, especially for additional population, could be a heavy burden on existing ratepayers.

149 In areas without main drainage, overflows from cesspools or discharges from septic tanks may cause pollution of ditches and streams. The increasing use of water aggravates the problem and can cause severe local pollution. (See also Chapter 6).

150 Another type of discharge direct to the rivers is from small private domestic sewage treatment works, which have been erected by developers in the absence of main drainage. Satisfactory maintenance of these installations is a particular problem, for when the developer has sold the houses, he has no further interest in the plant and, when the effluent is unsatisfactory, it is difficult for river authorities to get an improvement. Local authorities have the power to adopt these works, but sometimes the price local authorities are asked to pay makes them unwilling to do so.

151 Pollution of non-tidal rivers by the discharge of untreated sewage from boats, already mentioned above, is not so generally harmful as the other sources of pollution mentioned, but there are places where the practice causes objectionable local pollution.

Industrial effluents below standard

152 The quality of industrial effluents discharged direct to rivers is more unsatisfactory than the quality of effluents from local authority sewage treatment works (Table 3, paragraph 145). Here again, river authorities prefer to use persuasion rather than prosecution. Though more industrialists have been prosecuted than local authorities, it is difficult for river authorities to insist on the standards required for industrial discharges if the discharges of the local sewage authorities are not up to standard. The maximum penalty of £100 for a first offence is not a great deterrent, and in fact penalties of about £20 are much more usual. We recommend that the maximum penalties should be substantially increased and hope that the actual penalties imposed will be commensurate with the seriousness of the offences.

153 The particular problems of industrial and agricultural discharges are discussed in Chapter 7. Although most of the main agricultural discharges are now covered by the consent conditions of the river authorities, it is probable that there remain many small untreated discharges of farm waste without consent of the river authorities.

Accidental discharges

154 Accidental discharge of toxic substances can cause acute pollution of rivers and occurs frequently. For example, about 35,000 fish were killed by the escape of cyanide from industrial premises, which drained through a local authority sewage treatment works discharging to a river used for drinking water. The warning was sounded by anglers who saw the dead fish. The intake for public supply was fortunately closed before the cyanide reached it. The penalty imposed on the manufacturer for a breach of the Salmon and Freshwater Fisheries Act was £25, with costs. There was a conditional discharge for the offence under the Rivers (Prevention of Pollution) Acts.

155 The accidental discharge of oil inland is also increasing everywhere. Oil traps are provided at service stations on motorways but no traps or bund walls are required in England and Wales (unlike Scotland) to prevent oil leakage from installations. Road accidents to tankers carrying oil or toxic substances can cause river pollution if the toxic substance is hosed down by the Fire Brigade. Recommendations are made on this subject in Chapter 7 paragraph 382.

Controls and policies

156 The powers for the prevention of pollution exercised by river authorities, and the increased expenditure by sewage disposal authorities and by industry on treating liquid waste before discharge, have undoubtedly checked river pollution, but it is still widespread. The 1961 Rivers (Prevention of Pollution) Act was described by its sponsor as an essay in gradualness, and sub-standard discharges to rivers have been tolerated. The pressure on the water resources in our rivers now demands a more positive policy to prevent pollution and thus to make the best use of our rivers and canals for all their functions—for water supply, for natural drainage, for draining sewage and industrial effluent, for recreation and amenity, and for navigation. As the British Waterways Board owns the canals, the river authorities should consult the Board on plans for improvement of the quality of canal water.

157 In order to implement a more positive policy, we consider that a stronger integrated system of management is needed for the planning of the use and development of our water resources, which would cover both water quality and water quantity. As local government reorganisation is imminent, it is apparent that there will be changes in the administration of sewage disposal. The Central Advisory Water Committee has been reappointed to consider the future pattern of organisation of public authorities for sewage disposal, prevention of pollution, water conservation and water supply. We discuss in Chapter 9 the weaknesses of the present system of administration of sewage disposal and make recommendations on the principles on which future organisation should be based.

158 A national plan for water should set out clear priorities for action to improve river water quality. Firstly, current discharges should not increase the incidence of pollution since, as a matter of principle, we do not think it right that one generation should foul the environment for future generations. Secondly, higher standards of discharges will be required to rivers which are needed for water supply, whether for domestic, industrial or agricultural use. In order to prevent problems arising from eutrophication, higher standards of discharges may also be needed to rivers which feed storage reservoirs. Thirdly, rivers must be improved to fit them for recreation and enhance amenity. There will be more need to provide for leisure pastimes in the future and water-based recreations are likely to generate great increases in demand[7]. Methods of assessing the value of recreation in economic terms are now being developed and recreation should become a dominant factor in the calculations of the cost-benefit of river improvement. Finally, some contribution should be made to the reclamation of rivers misused in the past, when ignorance,

irresponsibility and greed used industrial technology to produce goods with little regard to any effect on the natural resources and processes on which human life depends. Both ecology and industrial technology can be used to work with nature rather than despoil it.

159 The higher standards of discharges needed to fulfil these priorities will require greater expenditure on water pollution control. Despite all the other competing claims on national resources, we are convinced that this expenditure is justified. In order to keep pace with the increasing volume of waste water, while abstraction of river water also increases, it is clear that we will have to spend more on sewage and industrial waste treatment if we are not to further damage our freshwater resources. Increased expenditure on the treatment of liquid wastes will be justified in particular by the need to enable rivers to supply water for domestic, industrial and agricultural use. The cost of river water improvement will often be the necessary complementary outlay to other expenditure on providing recreational opportunities, or on improving the environment for living and working.

160 Our proposals will also require greater expenditure on the treatment of industrial effluents. Pollution by industrial effluents causes social and economic costs to the community as a whole and the cost of treatment of industrial effluent to an acceptable standard must form a part of the normal costs of production. British industry has understandably expressed the fear that unnecessarily onerous effluent costs might significantly weaken its position relative to its principal foreign competitors. In our opinion the need to halt and control pollution of the environment is now so internationally recognised that British industry is unlikely to find itself in a disadvantageous position in this respect as long as international standards are effectively sought.

161 The legal powers to control discharges illustrated in Diagram 5, are as comprehensive here as in any other country, but experience has shown difficulties in enforcing them. We therefore propose that there should be additional legal powers and penalties which should make enforcement more effective.

162 As sub-standard discharges from sewage treatment works are frequently due to overloading, we recommend that there should be a legal obligation to provide adequate sewage treatment capacity for *all new development*. Sewage disposal authorities would however be unable to prevent their treatment works becoming overloaded if the present absolute right to connect properties to the public sewers remained. We suggest therefore that the right of connection be modified by requiring property owners to give local sewage disposal authorities notice of the intention to connect to the sewers. If the capacity of the treatment works were insufficient to take the additional load, the sewage disposal authorities would then have time to increase the capacity before the new connections were made. To prevent the right of connection being unduly delayed by this procedure, property owners should be given the right to appeal to the Minister of Housing and Local Government, when connection is refused.

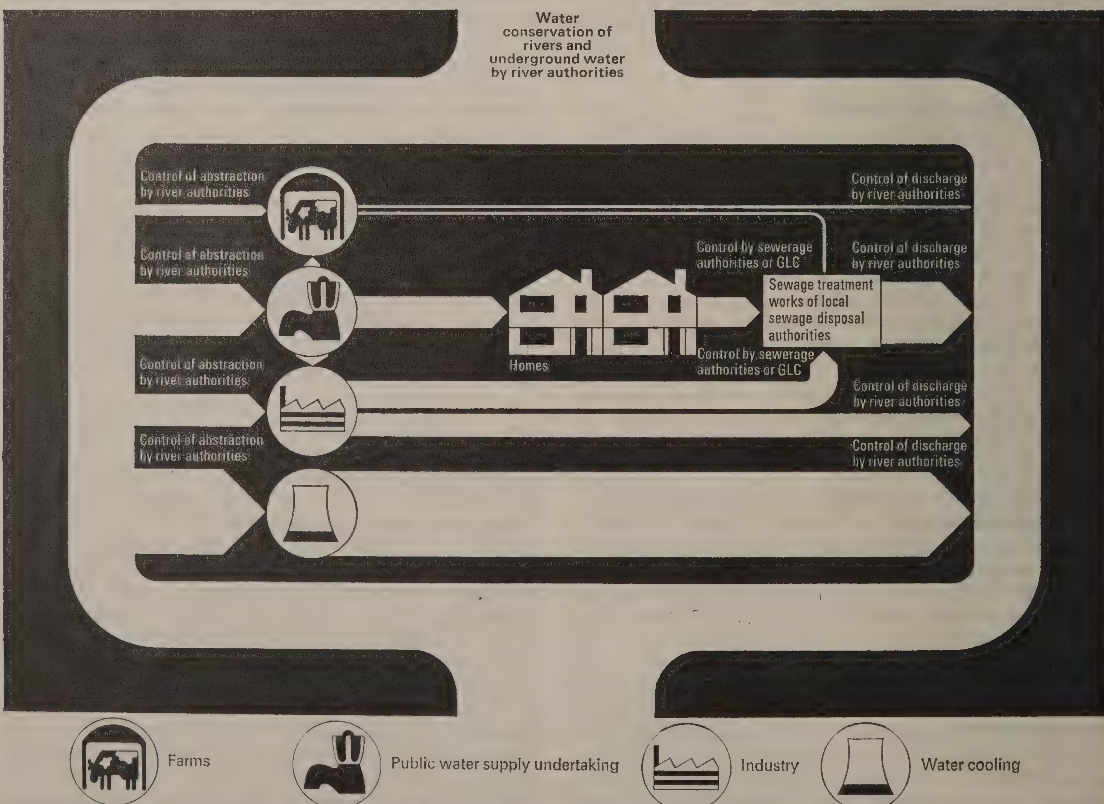


DIAGRAM 5 Control of abstraction from and discharge to freshwater

163 If the housing and industrial development necessary for the future is not to be delayed by lack of sewage treatment capacity, the authorities concerned must be in close touch with each other. For this reason we recommend that planning authorities should have the statutory duty to consult whatever authorities are responsible for river management and for sewage disposal about plans for new development.

164 Applications to discharge to inland watercourses should be advertised in the same way as water abstraction applications, so that all users of a river can be informed in case their interests are affected.

165 We have received evidence on the anomalies which arise from the occasional exercise of the common law rights of riparian owners. These rights entitle owners to receive water without sensible diminution of quality or quantity from that which they are accustomed to receive. Inland local sewage disposal authorities have no alternative but to discharge sewage effluent to watercourses, but the exercise of riparian rights has occasionally caused them to resite their discharges at considerable expense and with no overall benefit. On the other hand the exercise of riparian right has occasionally improved the quality of the discharges, with some general benefits. There is no readily available information to show whether the benefits of the exercise of riparian rights outweigh the costs. We do not therefore make any recommendation on the subject but think it needs further investigation.

Recommendations

166 A more positive national policy is required to ensure freshwater *quality*, integrated with the forward planning for water *quantity*, both nationally and locally. Stronger central and local administrative authorities will be required to implement this plan. (Paragraphs 156–158).

167 The statutory duty of the authorities responsible for water resources to carry out a survey of the water resources of their area (Section 14 of the Water Resources Act 1963) should in future include:

i. The assessment of the quality of the waters in their rivers, and of the standards of quality required related to the uses of their rivers, including their recreational potential. (Paragraph 158).

ii. A programme for improvement of quality as necessary, with stated priorities, but the first priority should always be to avoid any increase in pollution. (Paragraph 158).

iii. A similar survey of the quality of canal water, in relation to its uses, in co-operation with the British Waterways Board. (Paragraph 156).

168 The authorities responsible for water resources should strictly control the quality of discharges according to their agreed programme of improvement. (Paragraph 158).

169 To ensure that sewage treatment works will be planned to keep pace with new development, planning authorities must be required by law to consult the authorities responsible for river management and for sewage disposal on all plans for new development, which must never be allowed without simultaneous provision of adequate capacity for sewage treatment. (Paragraph 163).

170 The automatic right of connection of domestic properties to a public sewer should be withdrawn and replaced by a sewer connection notice procedure. (Paragraph 162).

171 Applications to discharge to inland watercourses should be advertised in the same way as water abstraction applications. (Paragraph 164).

172 The maximum penalties on dischargers who fail to comply with the river authority's consent conditions should be substantially increased. (Paragraph 152).

173 Discharge of sewage from boats into watercourses used for water supply or recreation should be prohibited. (Paragraphs 117–119, 151).

174 The expansion of existing industries or the siting of new industrial premises for the manufacture of fine chemicals, pharmaceutical or agricultural chemicals should be carefully controlled where these industries have to discharge trade effluents directly or indirectly into rivers used as sources of public water supply. Planning authorities should be required to consult river authorities on the siting of these industries. (Paragraph 128).

175 Research should be put in hand to examine the effects on plant growth and on soil structure of mineral salts present in polluted river waters used for irrigating crops. (Paragraph 141).

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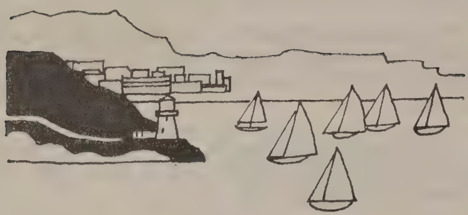
Chapter 4 Sewage Disposal to Estuaries and Tidal Rivers



Character of estuaries and tidal rivers

176 As a river flows into the sea, its salinity at any point depends on the state of the tide, the flow of fresh water and the wind. In some estuaries there is marked stratification of fresh and salt water, with the fresh water tending to flow out over the denser salt water. The shape of an estuary, the volume of the flow of fresh water and the extent of tidal flushing all affect its capacity to accept pollutants. Where the flow down to the sea is hampered, pollution can pass upstream and downstream with each succeeding tide for some time before being washed finally out to sea. In general, the turbulence due to the tides and the salt content allow estuary water to absorb more pollution than river water, apart from the greater volume of water in estuaries than in rivers.

177 In some cases, as in Poole harbour, it is easy to define when the seaward limit of an estuary is reached. It is not usually so easy to draw a line between an estuary and the open sea, but the seaward limits of estuaries are defined for statutory purposes (see paragraph 199).

Various uses of estuaries and tidal rivers

178 By definition, estuaries are outfalls of rivers to the sea. Navigation is probably their most significant single use and many of our major cities are sited on estuaries because of the great importance of transport by sea.

179 Estuaries supply cooling water for industry and power stations and receive large volumes of discharges of industrial effluents, sewage effluent and/or untreated sewage.

180 Other uses vary considerably according to the nature of the estuary. Recreation, such as boating, is rapidly increasing in many estuaries—for example in Southampton Water, the Fal estuary, Poole harbour, Chichester harbour, the Medway, the Crouch and the Blackwater. Bathing and angling are also popular. A considerable number of estuaries in England and Wales are particularly suitable for the production of shellfish which require the sheltered conditions which they provide (eg Bangor Flats, the Fal estuary, Poole harbour, the Thames, several Essex estuaries, the Wash). These shellfisheries altogether yielded about £400,000 at first sale in 1968. The total value of all commercial fishing in estuaries is over £1,000,000 at first sale a year. Estuaries are the only way for salmon and eels to enter our river systems, where the salmon have their spawning grounds.

181 Although the character of a tidal river near the limit of the tidal section is not sufficiently different from the non-tidal river above the limit to affect its recreational use, the distinction between tidal and non-tidal rivers is significant as public water supply is not drawn from saline (tidal) sources.

Extent and causes of pollution in estuaries and tidal rivers

182 For many years estuaries have been regarded as capable of taking virtually unlimited polluting loads—probably because it was erroneously believed that their salt content had special purifying powers. Consequently effluents have been discharged without treatment, which has resulted in very severe pollution, especially where large conurbations exist on, or near, the mouths of rivers (see Plate 3).

183 The 1958 river pollution survey (referred to in Chapter 3) found that tidal rivers to the then seaward limits were more polluted than either non-tidal rivers or canals (Table 4). As the information collected was less complete than for rivers, the figures are less precise and should be taken only as a general indication of the state of tidal rivers and estuaries in 1958.

Table 4. Degree of Pollution in Tidal Rivers and Estuaries, 1958

[Ministry of Housing and Local Government informal survey]

Class	Condition	Miles	Percentage of Total
1	Clean	720	41
2	Doubtful	580	33
3	Poor	250	14
4	Grossly polluted	220	12

184 There are some badly polluted estuaries in the conurbations—the Mersey, Tees and Tyne. The Thames

has improved lately, due to the extension of full sewage treatment in the works owned by the Greater London Council. Other heavily polluted estuaries are the Wear, Humber, Severn, Usk and Ribble. The only major estuary in the country which is not significantly polluted is the Solway Firth, containing the Esk and Eden estuaries.

185 Estuaries can be polluted by the discharges into them and by the polluting loads brought down by the rivers which flow into them. In the tidal Thames, for instance, the main cause of pollution has been discharges from local authority sewage works which have not been fully treated. In 1950–3 a special study showed discharge from local authority sewage works amounted to 440 mil gal (2 mil m^3) a day, contributing about 73 per cent of the pollution load. Industrial discharges contributed about 9 per cent; the tributaries about 8 per cent. The remainder was contributed by storm overflows. The polluting load from the sewage works has since been significantly reduced.

186 In the upper reaches of the Humber estuary, the main cause of pollution is the polluting load brought down by the rivers Trent and Ouse, each contributing, under low flow conditions, about 200 tons of effective oxygen demand a day, which is equivalent to the amount of oxygen dissolved in some 5,000 mil gal (23 mil m^3) of sea water. This can reduce the dissolved oxygen to a very small percentage when the freshwater flow is low.

187 The Tees estuary regularly receives 500 untreated discharges. It was a good salmon river until the first world war. The tidal Tyne on an average day bears 37 mil gal (170 mil l) of sewage from local authority sewers and 10 mil gal (45 mil l) of trade waste, discharged through 270 outfalls altogether. A survey made by the University of Newcastle upon Tyne has indicated the tremendous bacterial pollution, not only of the estuary, but also extending a distance of 5 miles out to sea[2]. On the Welsh coast of the Severn estuary there are 90 outfalls discharging sewage and trade waste from 1·1 million people, 40 per cent of the population of Wales. Only seven of the discharges are fully treated and nine are partially treated.

188 Where boats are concentrated, pollution from discharges of their untreated sewage can cause obnoxious local conditions, as the working party have observed. Naval vessels discharge untreated sewage which could cause pollution where they are concentrated, for example on the Medway. In estuaries, ships may discharge bilge water and cause local pollution, as on the Tyne.

Effects of pollution on estuaries and tidal rivers

On amenity

189 A grossly polluted estuary like the Tyne is not attractive for recreation. Sometimes the water smells offensively, particularly where untreated sewage is discharged. The refuse deposited on the banks is not only unsightly but may cause water pollution. About a quarter of a million people live within three-quarters of a mile from the banks of the last 16 miles of the Tyne estuary, and thousands work right on its banks, in shipyards, factories and on wharves. After a conference in 1963 the Tyneside authorities decided to commission a plan for the renewal of the riverside. A plan has now been prepared by a landscape consultant, and improvements to the river banks have started. Meanwhile, proposals for a sewerage scheme which may cost over £40 million have been prepared. Intercepting sewers will take all discharges into treatment works and sludge will be piped or carried out to sea; sixty pre-1960 industrial discharges will however continue unaltered unless the legal powers of control are extended to cover them. A decayed, drab environment is no longer acceptable and cleaning up the Tyne estuary is part of urban renewal, which will rehabilitate both derelict land and polluted water.

190 In other estuaries, like the Solent, where the water is not on the whole badly polluted, the recreational use of the water is more general. But if pollution is not checked the state of the water could inhibit leisure use and another recreational resource would be wasted. The creation of alternative opportunities for recreation could be costly.

191 The Greater London Council (GLC) and private developers are spending millions of pounds on residential and recreational developments on the banks of the tidal Thames. For people in the new town of Thamesmead "the river will be at their doorstep—part of their way of life"[3]. As some of the old docks are no longer required, areas like St Katherine's on the Thames are proposed for redevelopment for residential, recreational, culture and business purposes. The buildings would be grouped round a marina of estuary water. Such developments, which could occur on all the estuaries in conurbations, are hardly likely to be successful in attracting residents and users for their expensive facilities if the water is objectionable. The GLC's large-scale expenditure on sewage treatment should suitably maintain the water in the Thames estuary to the required amenity standards.

The risk from bathing in tidal rivers and estuaries

192 The risks to public health from bathing in the upper reaches of tidal rivers are not greatly different from the risks, already mentioned, of bathing in non-tidal rivers.

193 The degree of risk from bathing in the lower reaches of estuaries may be similar to that in other coastal areas, which are discussed in the next chapter. But in heavily polluted estuaries the pollution may be even worse than in rivers where bathing and swimming is regarded as undesirable. Bathing and recreational beaches do however occur in some heavily polluted areas.

194 Estuarial pollution can affect the bathing beaches of coastal resorts near the mouth of the estuary. There is, for instance, visible pollution at times on beaches near the mouth of the Tyne Estuary and very high coliform counts have been recorded between the piers at North and South Shields. In both cases, the pollution appears to be brought down the estuary.

On shellfisheries

195 A number of valuable shellfisheries are found in estuaries, in the sheltered conditions they require. Among these are the filter-feeding molluscs (ie oysters, mussels, clams, cockles and scallops) which concentrate particles, including bacteria, in their bodies. Where an estuary is polluted with sewage these shellfish become polluted and are made unsuitable for human consumption. There has been a long history of enteric disease in man from their consumption. This public health hazard has been countered by the Public Health (Shellfish) Regulations 1934 which allow local authorities to make orders that prohibit the sale of shellfish from grounds which have been polluted, unless the shellfish have been cleansed, sterilised or relaid in clean water. Under these regulations many shellfish grounds in estuaries or enclosed coastal waters have been partially or completely closed. Oyster fishing in the Tamar and Lynher rivers has been stopped. Pollution has imposed

considerable marketing problems on oyster fisheries in many areas including the River Colne, the upper Blackwater, the River Roach, Whitstable and Poole Harbour. Mussel fisheries have been affected, for example at Lytham, Morecambe and Exmouth, and particularly severely in the Wash. Up to 1970 there have been eleven compulsory orders for oysters, and more for mussels and cockles, requiring cleansing, sterilising or relaying.

196 We recognise that a number of our estuaries have a considerable contribution to make towards our supplies of fish and shellfish, and pollution should be controlled so that these are not harmed. Where there are fisheries for filter-feeding shellfish, added attention may need to be given to keeping down the level of sewage bacteria.

197 The value of shellfisheries destroyed or impaired cannot be known, as the insidious contamination has been spreading for many decades. But it is clear that both the actual and the potential value of shellfisheries has been severely reduced by pollution. In France 1,400 million oysters were sold in 1967 at a value of £23 million, while the United Kingdom waters produce only 5 million oysters a year (evidence from the Shellfish Association of Great Britain).

198 Severe estuarial pollution also inhibits salmon and migratory trout fishing in the whole of the river system draining into the polluted estuary, as migratory fish will not make their way up through a barrier of pollution.

Control of pollution in estuaries and tidal rivers

199 Under the Rivers (Prevention of Pollution) Act 1951 the Minister of Housing and Local Government had power to make an Order on the application of a river authority to give it control over new discharges to estuaries and to take all the other pollution control powers in the Act. Only a few Orders were made, generally controlling new discharges. As the pollution of some estuaries continued to increase river authorities were given a general power, by the Clean Rivers (Estuaries and Tidal Waters) Act 1960, to control new and substantially altered discharges, up to the seaward limit of each estuary of any significance as defined in the schedule to the Act.

200 Sea Fisheries Committees can exercise control of pollution, through bye-laws, to protect fish and shellfish from pollution by industrial discharges. However, local authority sewage discharges are not covered by these byelaws and the control has not always been effectively applied.

201 The Minister and the Secretary of State for Wales have power, under the Rivers (Prevention of Pollution) Acts 1951 and 1961, on application by a river authority, to make "Tidal Waters Orders" to give the river authorities full control of both new and existing discharges. Fourteen Tidal Waters Orders have been made, but none in the major estuaries. The Thames estuary has been controlled by the Port of London Authority since 1909, and came under full control in 1968 under powers in the Port of London Act 1964.

202 We consider that the time has now come when tidal rivers and estuaries should be subject to comprehensive pollution control. As many of the major grossly polluted estuaries are in the conurbations, their condition spoils the environment of millions of people. Their use for recreation and for shellfisheries has been inhibited by excessive pollution. As we have already argued in Chapter 3 on rivers, the quality of the environment and recreational opportunities are likely to be of increasing importance in this country in the future. We do not think the existing Tidal Waters Order procedure suitable for extending comprehensive control to all estuaries. We therefore recommend general legislation to apply to all tidal rivers and estuaries, including those not covered by the schedule to the 1960 Act, which would bring them under the same form of pollution control as applies to non-tidal rivers, under the Rivers (Prevention of Pollution) Acts 1951 and 1961. Thus all pre-1960 discharges as well as new discharges would be subject to control.

203 The river authorities exercise the existing powers to control pollution in all except the very small estuaries. Therefore they should be given the extended powers of control. However, river authorities often do not have the knowledge of the estuarine environment which is particularly necessary where there are shellfisheries or other fisheries. River authorities are now obliged to consult Sea Fisheries Committees on pollution which may affect fish in estuaries, but it appears that in some cases inadequate consultation has prevented the full benefit of the Committees' expert knowledge being realised. In the next chapter we are recommending that the authorities responsible for river management should be given power to control discharges to the sea. River authorities will therefore have to be reconstituted and renamed. The new staff they will require should include people with knowledge of estuarine as well as of the marine environment.

204 We recognise that cleaning polluted estuaries will be costly. Sewage disposal authorities will have to spend large sums to treat adequately all effluent from sewage works. The GLC may have to spend £100 million altogether, the Tyneside authorities more than £40 million, and the Teesside Authority more than £20 million on its current proposals.

205 Some industrial undertakings will also have to pay more for treatment or disposal of their effluent. Altogether, however, the burden will not amount to any more than the same order of costs which inland communities and industries, and new dischargers to estuaries, already have to incur.

206 The abatement of pollution in tidal waters and estuaries would bring the same benefits in amenity as the abatement of pollution of non-tidal rivers. It is probable, indeed, that there would be additional benefits in amenity from cleaning estuaries, since it would improve the environment of people whose work places are on the banks, result in cleaner beaches close by and perhaps open the rivers again to migratory fish.

207 As discharge of sewage from ships can cause local pollution in estuaries we recommend that such discharges should be prohibited, by the river authorities, where necessary. The prohibition should apply to all vessels, including naval vessels. Port authorities could make similar arrangements for waste disposal points as on the Thames estuary, and these would need to be supplemented by similar arrangements at boat yards and marinas. We support the Inter-governmental Maritime Consultative Organisation, a United Nations agency, in their efforts in this direction.

Recommendations

208 Responsibility for the control of all pollution by discharge or dumping in estuaries and tidal rivers should be vested in the authorities responsible for water resources,

with adequate additional powers and duties and experienced staff. (Paragraphs 202, 203).

209 Most authorities responsible for water resources will require to be better informed on marine estuarine fisheries (see also Chapter 5 paragraph 269). Their consultation with the Sea Fisheries Committees should be improved. Where fisheries of filter-feeding shellfish occur, bacterial loadings and positions of outfalls will have to be taken into account before granting consents for discharges. (Paragraph 196).

210 Discharges from ships, including naval vessels, into estuaries and tidal rivers should be controlled where necessary by the authorities responsible for water resources. (Paragraphs 188, 207).

211 The survey by the authorities responsible for water resources proposed in the second recommendation at the end of Chapter 3, should include tidal rivers and estuaries.

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Chapter 5 Sewage Disposal to the sea

Uses of sea water and the seaside

212 The great volume of the sea has encouraged its use for the disposal of liquid and solid wastes, but care has to be taken to avoid harmful effects from these wastes, especially as it is usual to discharge them into coastal waters near the land.

213 With the greater mobility of the population, more people are going to the seaside for recreation. Coastal waters are among the most productive fisheries and include nursery grounds for many offshore fish. There are shell-fisheries for oysters, mussels, clams and shrimps in protected inshore waters as well as in the estuaries, and lobster fisheries are found by rocky coasts.

Methods of sewage disposal to the sea

By sewage disposal authorities

214 At present, the sewage and trade waste from a population of about 6 million is discharged directly to the sea or to estuaries, with only partial or no treatment. There is no exact information available about the methods of discharge but some facts were produced as a result of surveys by the Ministry of Housing and Local Government in England in 1965 and 1966 and by the Welsh Office in 1967. Local authorities were asked for information, but the surveys do not show the population served by each method, nor give details such as the length of outfalls, nor attempt to evaluate the methods of discharge.

215 The surveys show that about two-thirds of the local authorities which discharge sewage to the sea, discharge at least some untreated sewage. Coastal towns usually slope towards the sea, and as sewers were laid, they followed the ground contours and fell towards the shore. There are some instances where these sewers all discharge to the beach, but usually they have been joined by an intercepting sewer parallel to the coast which terminates in one or more outfall pipes. These sometimes end and discharge the sewage on the beach, but the majority of coastal communities are believed to discharge their sewage, at, or not very far below, the low water mark. There are very few local authorities which have constructed outfall pipes discharging any considerable distance from the shore.

216 As the growing volume of sewage has increased beach pollution, many coastal local authorities have made improvements in their arrangements for sewage disposal. For example, large visible solids such as faeces, sanitary towels and contraceptives have often been removed by screening before discharge, or the solids have been broken down by macerators or comminutors. Settlement has been used to remove the gross visible solids and also a large proportion of the solids in suspension. These methods not only prevent visible pollution, but enable the polluting matter to be more readily diluted, oxidised and purified by natural processes in the ocean. The surveys showed that about a third of the local coastal authorities partially treated at least some of their sewage by one or more of these methods.

217 In a few places, known to number ten in England in 1965–66, holding tanks have been constructed which retain the sewage during periods of unfavourable tidal currents and discharge it at times when it will be carried well out to sea.

218 Among the 148 local authorities in England which were shown by the survey to discharge to the sea, 22 had full treatment works. In Wales the survey found seven local authorities out of 44 discharging to the sea had full treatment works.

219 Since the information was obtained for these surveys four local authorities in Wales and twelve in England have had new schemes approved. In England, the cost of these schemes will be over £5 million for an aggregate resident population of about 500,000, which is likely to more than double in the holiday season. New methods of pipe laying have recently made it easier to construct long sea outfalls and five of the English schemes will have pipelines one to three miles long. One of the new English schemes will give full treatment to the sewage. In Wales five of the new schemes will have long pipelines and two will have full treatment works.

Other types of discharge to the sea

220 There are probably thousands of private discharges of domestic sewage to the sea ranging from outfalls from one private house to outfalls from large hotels, holiday camps and caravan and camping sites not connected to main drainage. These discharges are usually made through short outfalls

sometimes even above high water mark, though some holiday camps use storage tanks and discharge only on the night ebb tide. Industrial effluents of many kinds are discharged directly to the sea, including wastes from iron and steel works, paper industries, manufacture of antibiotics and other drugs, tanneries, engineering and ship building, oil refineries, cellulose manufacture, heavy and light chemical industries, food processing and fish meal production. Industrial firms with effluents difficult to treat and dispose of inland are tending to establish themselves in coastal areas where they can at present get rid of their wastes easily and cheaply. Coastal local authorities may receive toxic industrial effluents into the sewers under a trade effluent agreement because their methods of disposal do not include biological processes. Care must be taken that large quantities of highly toxic waters do not enter the sea in this way, either legally or illegally.

221 Some thousands of tons of sewage sludge are dumped into the sea every day, largely in the outer Thames estuary and Liverpool Bay. It has been decided to dump sludge also in the Severn estuary. Industrial and chemical wastes are dumped at selected spoil areas on the continental shelf or are taken in weighted drums on transatlantic ships to be dumped beyond the continental shelf in water of at least 2,000 fathoms (4,000m) deep.

Pollution of beaches and bathing waters

222 Wherever sewage is discharged to the sea without treatment and through short sea outfalls, it can be washed back to the beach with virtually no dilution.

223 The only evidence submitted to us specifying the extent of dirty beaches was from the National Association of Parish Councils, which asked its members for information on pollution of beaches. Some 430 questionnaires were sent to parishes which were on the coast, though many covered only short lengths of coast-line or did not have a beach. Altogether 208 replied and 138 reported no fouling of their beaches, while 70 (one-third) replied that there was pollution of the beaches. Serious pollution was mentioned by half of those complaining, and it appeared that well-frequented beaches on the south coast of England were the most noticeably affected by sewage residues brought in by the tide. The source in most cases was alleged to be the outfall of a neighbouring urban authority! In its evidence, the Coastal Anti-Pollution League listed nearly 200 resorts about which the public had complained in the last ten years.

224 As there is no control of local authority coastal discharges and no systematic monitoring of the conditions on beaches and bathing waters, we are not able to estimate the actual extent of pollution. By the nature of the sea and the climate, pollution can often be intermittent rather than constant. Some short outfalls may cause local pollution, but in places which are inaccessible. Others, by virtue of tides, currents or winds may not in fact cause beach pollution at all. But there is incontrovertible evidence from many sources of a significant amount of pollution around our coast. Unless the pollution is visible, the ordinary public have no means of knowing which particular beaches are polluted.

Coastal discharges and amenity

225 The sight of crude sewage on beaches or in the sea is objectionable. We have had evidence that besides faecal matter and dirty paper, contraceptives and sanitary towels are sometimes visible on beaches. All the organisations submitting evidence on coastal discharges urged that these unacceptable practices should stop. The number of complaints received by the Coastal Anti-Pollution League, the survey already quoted by the National Association of Parish Councils, the evidence of the National Federation of Women's Institutes and of the National Union of Townswomen's Guilds, give many actual examples of offensive pollution.

226 We agree with the Coastal Anti-Pollution League that people have a natural aversion to any contact with excreta and nowadays they accept without question that contact with human faeces is to be avoided in the interest of hygiene.

227 Complaints about pollution at seaside places are not as frequent as we would have expected when we saw some of the worst conditions. Most people affected are not local residents but holiday-makers, often on day-trips, who do not want to use their time making complaints. As already mentioned, gross pollution is often sporadic and spasmodic so, unless it persists throughout a holiday, people may think it accidental. On the whole people tend to trust their local authorities and if pollution is not obvious they would find it difficult to believe that public health authorities were allowing children to paddle in sewage or were acquiescing in sewage spray blowing over the promenade. We found some local authorities whose members appeared to be quite complacent about the gross pollution of their beaches, and were indifferent to public reaction as they had received few complaints. In contrast there were other local authorities with active Medical Officers of Health who made it their business to watch carefully the effects of sewage discharges on the beaches and bathing waters, and to carry out regular inspections. In other places inspections were made only after complaints. We do not consider this procedure satisfactory as many visitors complain silently only by not revisiting, and do not contact the authorities.

228 We cannot accept that conditions on our beaches should be below the standards of hygiene and decency that we expect in our homes, streets and workplaces.

Health hazards of sea bathing

229 The possibility that bathing on beaches polluted by sewage may carry risk of infectious diseases has caused public anxiety, and has prompted considerable debate as to the extent of such a hazard. The fear has a rational basis because raw sewage contains large numbers of organisms, some of which can be pathogens. When beaches are fouled by faeces, paper and other sewage contents, anyone bathing in these areas could be exposed to these agents. It is confirmed by evidence from many sources that samples of sea water can contain a variety of intestinal pathogens. The question that arises is whether these pathogens are present in sufficient number so that a bather could swallow an infective dose. This is difficult to answer except in general terms.

230 The number of organisms required to infect a person cannot be stated with certainty. It is greater for some diseases than others, but in general a large dose is more likely to infect than a small one. Providing the concentration of pathogens is low, the risk of infection from bathing is very small.

231 The most important factor reducing the concentration of organisms reaching a beach is the mixing and dilution of sewage in sea water. Another factor is the size of the particles of sewage. The smaller they are, the more likely the bacteria will be destroyed. How much dilution occurs will depend on the site of the discharge relative to the beach, on the design of the diffuser, and on winds, tides and currents.

A secondary factor is the natural decay of pathogens in sea water; their death rate, which varies according to species, is influenced by temperature, sunlight, and salinity. The composite effect of these factors is that a particular beach may at different times experience a wide range in the concentration of pathogenic organisms.

232 Although bacteriological examination of sea water would seem the obvious way of estimating the health hazards of bathing, the results of such examination are difficult to interpret and have not provided a satisfactory yardstick. Direct examination of samples of sea water for individual disease agents would be an enormous task, made even more impracticable because sampling would have to be almost continuous to cover changes in the situation at a beach, as indicated in the previous paragraph. It is customary to monitor samples of sea water by the presumptive coliform and faecal coliform (*Escherichia coli* type I) counts. The faecal coliform count estimates the concentration of organisms normally present in human and animal excreta, but the presumptive count includes in addition those derived from decaying vegetation, rotting timber, etc. Coliform bacteria are always present in sewage. Pathogenic organisms, on the other hand, appear sporadically depending on the prevalence of infections in the community. When present their rate of decay in sea water may differ from that of coliforms. In consequence, the coliform count cannot be used to predict whether disease agents are present or absent in sea water, nor in what concentration. A bacteriological standard for determining the health hazard of bathing is impracticable. A determination of the permissible limits of pollution must, therefore, in practice be indirect and refer only to the amount of sewage present. It is true that a relatively low degree of pollution may contain a high proportion of pathogens but the practicable way to keep the hazard to a minimum is to limit the degree of sewage pollution. The faecal coliform count in particular provides a rough grading of the degree of sewage pollution, and if obtained from a carefully planned survey with extensive sampling may be a useful part of the evidence used in determining whether an existing outfall is satisfactory.

233 In the history of many communicable diseases the existence of a hazard and the method of spread have been demonstrated by epidemiological studies without bacteriological confirmation, sometimes long before techniques were available for identification of the agents responsible. There might be hopes, therefore, that the question of how far sea bathing might be responsible for infection could be resolved by recourse to epidemiological data. There are however considerable difficulties in obtaining reliable evidence.

234 At various times claims have been made associating many infections with sea bathing, but in order to interpret such evidence correctly it is vital to recognise that all these diseases commonly arise in circumstances which have nothing to do with bathing. The presence of disease agents in sea water is, to a large extent, a measure of the distribution of these pathogens in the community at large, and epidemiological studies are therefore not looking for diseases distributed exclusively by the route of sea water. The question to be answered is how many of the infections in the community can be said to be spread by sea bathing rather than by other means.

235 The Public Health Laboratory Service Committee, which reported in 1959[1], looked carefully at enteric infection (typhoid and paratyphoid fevers), and could describe only a handful of cases, in the whole of England and Wales over the previous 5 years, in which sea bathing seemed the probable mode of infection. All of these occurred after bathing at beaches which were very heavily and visibly polluted. Other series from abroad, some of them much larger, also point to the possibility that sea bathing has been responsible for enteric fever. These countries have usually had a higher incidence of enteric disease with a high carrier rate of the organisms in the community. Again, gross pollution seems to have been a characteristic of most of the reports. Since enteric fever is a rare disease in this country now, the chances that sea bathers would be exposed to the agent must be quite small, and the risk of illness amongst them negligible.

236 Salmonella infections are much commoner than enteric fever but are nearly always contracted from food. As these organisms die fairly rapidly in sea water and a relatively large number is required for infection, the risk of acquiring this disease by sea bathing seems on pathological grounds to be low. Investigation of outbreaks almost always points to food poisoning, when the cause has been found.

237 Diarrhoeal diseases such as dysentery and gastro-enteritis of unknown origin are also relatively common. Some of the gastro-enteritis of unknown origin is almost certainly viral, but the part played by different viruses is not yet worked out. The mode of spread is also uncertain, and might be through direct person to person contact without an intermediate vehicle, or by means of contaminated food or drinking water. Diarrhoeal diseases are common afflictions of visitors to seaside resorts, also of all travellers, hence the term "travellers' diarrhoea". Many of the persons affected have not bathed, and it is likely that even at seaside resorts bathing could only be responsible for a small part, if any, of the infections that occur. The size of the problem has, however, never been adequately measured, for good reasons. Perhaps the most important is that many of those affected do not seek medical advice, and those who do will often consult their own doctor on their return home rather than one at the resort thay have been visiting.

238 From all these considerations, it seems that although our knowledge about the hazards that accompany sea bathing is inadequate, the problem does not appear to be of sufficient size at the moment to warrant the very large scale research that would be required to fill gaps between the bacteriological (and viral) evidence showing the presence of known pathogens, and the epidemiological evidence suggesting an absence of any effective health risk.

239 The situation might change however because of alterations in the common pattern of disease in the country. The population is increasing, and a larger proportion is living in the coastal areas. In consequence the total volume of sewage discharged into the sea will grow considerably. International movements of population may introduce infections which have become quite rare, and with the increase in foreign travel more of our people may bring infections back with them. Diseases such as infectious hepatitis, which have not seemed such an important problem here as in many other countries, may assume a new significance. Since this virus disease can be waterborne, and has been responsible abroad for infection through eating shellfish, it is clearly a disease whose epidemiological features must continue to be kept under review. Current evidence points to direct person to person contact as being the predominant mode of spread in a community.

240 For the present we have to accept an apparent conflict between the bacteriological (and viral) and the epidemiological evidence. *A priori*, the heavy pollution in terms of faecal (*Escherichia coli* type 1) coliforms of some bathing

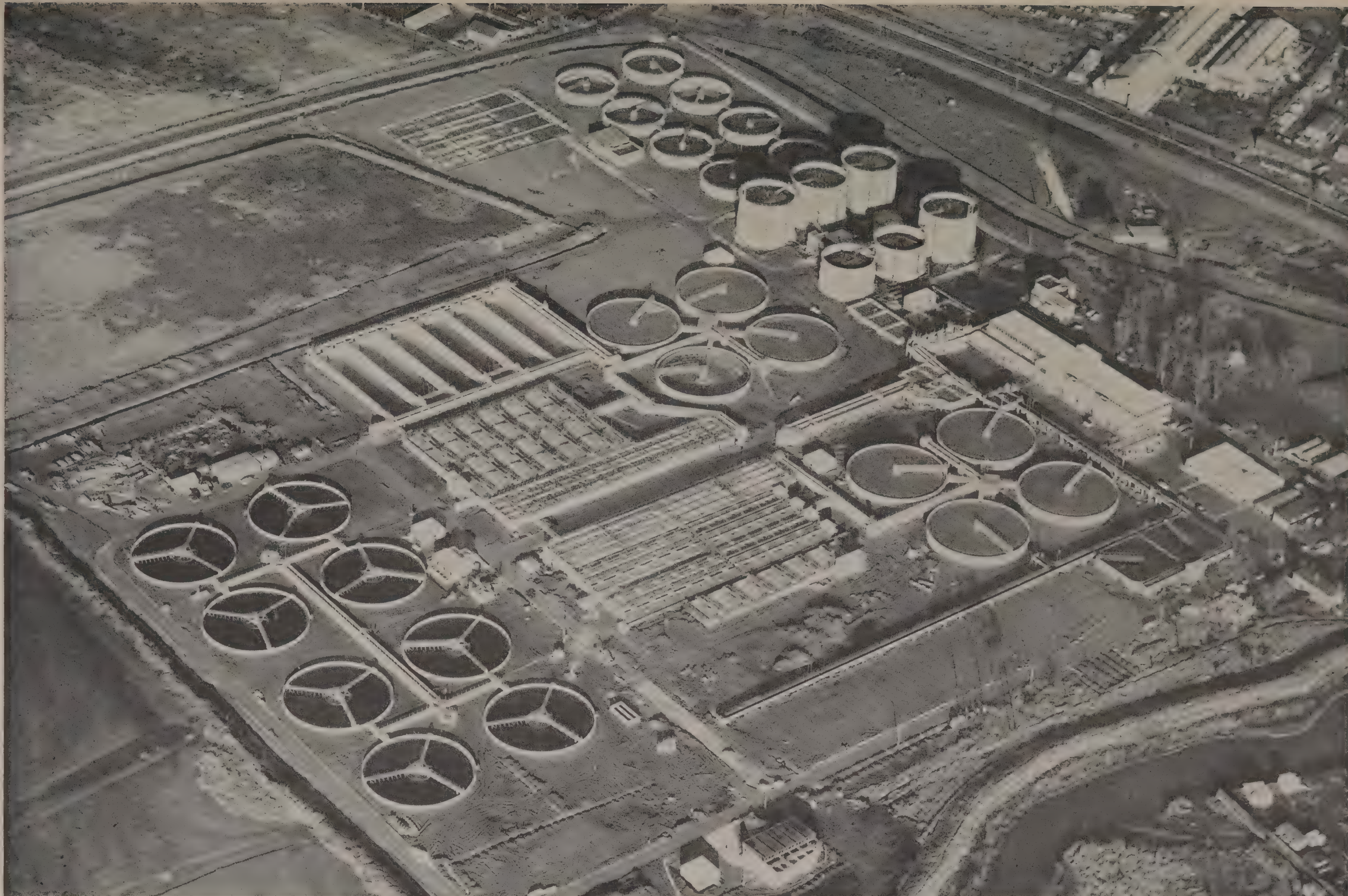


Plate 1. Aerial view of a large sewage treatment works (Greater London Council's Riverside Works) *see also diagram 3*.

Plate 2. A river in an industrial area

Plate 3. The Tyne estuary showing discharge from outfall.

Plate 5. Disposal of the contents of an earth closet.

Plate 4. An earth closet.

waters, even when not accompanied by gross visible pollution, would lead one to expect consequent infections; but the expectation does not seem to be justified by the epidemiological evidence available.

241 There is no reason at present to believe that the risk of disease is more than minimal. We cannot therefore recommend immediate priority for increased research on the disease aspects. But, pathological arguments apart, we cannot accept that dirty beaches are an inevitable part of our environment. We insist that people should be able to enjoy the beaches they visit, the waters in which they swim or on which they sail. They are entitled to find at the seaside the pleasure and recuperation and relief from tension which contribute positively to good general health of mind and body. Anything avoidable which detracts from personal relaxation and individual enjoyment of our incomparable coastline should be eliminated.

Effects of sewage and industrial wastes on marine life, including fisheries

242 The discharge of sewage and industrial waste to estuaries and the sea can affect marine life and fisheries in two main ways. They can adversely affect the growth and survival of animals and plants or they can render commercially useful species unsaleable by polluting or tainting them.

243 Domestic sewage itself does little damage to marine life and to a certain extent acts as a fertiliser, but in sheltered waters its oxygen demand can have the same harmful effects as in rivers. The pollution of filter-feeding shellfish by sewage bacteria has been discussed in the previous chapter as it is primarily a problem of estuaries. But where shellfisheries occur in open waters, as at Whitstable and Bangor, the same principles apply. While sewage is unlikely to harm lobsters, it can foul the gear for hauling in lobster pots.

244 Sewage sludge can also be an important carrier of pesticides to the sea. These are adsorbed on to the organic matter; where large quantities of sludge are dumped levels of pesticides could be reached which would harm the marine life in the area.

245 Industrial wastes containing heavy metals, phenolic substances, cyanides and some of the new complex synthetic organic chemicals are toxic to marine life: at low concentrations they can reduce the diversity of marine species and at higher concentrations also reduce the amount of life which can survive.

246 In the sea it is rare to get visible fish kills from pollutants, as many animals that might be killed will move into deeper water and most that are killed are quickly consumed by scavenging animals. Also pollutants affect the young animals first so that increasing pollution leads to a steady depletion of marine life without any obvious signs of dead or dying adult animals. At present measurable depletion of marine life in the sea round the United Kingdom appears to be limited to the immediate vicinity of some industrial discharges, but for the reasons just described it is impossible to be sure that the effects are not in fact greater than can be readily assessed. In particular, there is anxiety about the very persistent and toxic organochlorine pesticides and such materials as the polychlorinated biphenyls.

247 Shrimp fisheries, worth over £200,000 in 1968, are usually found in estuaries and coastal waters and are affected by reduced oxygen levels or industrial wastes; and lobster fisheries, worth £383,000 in 1968, usually found in shallow coastal waters on rocky coastlines, are particularly vulnerable to industrial discharges.

Recommended methods of sewage and industrial effluent disposal in coastal waters

Sewage

248 To satisfy the standards we think are necessary for public health, amenity and the protection of fisheries, coastal discharges of sewage must meet the following conditions:

- Particles of sewage should not be able to reach the bathing areas;
- The point of discharge should be far enough offshore to render the sewage slick inoffensive to people on shore or in the bathing areas;
- The siting of outfalls should take local fisheries into consideration.

249 A few submissions of evidence suggest that all sewage should be fully treated before discharge to the sea, in the belief that the processed effluent will be innocuous and inoffensive. We have seen in Chapter 2 that the major aim of conventional sewage treatment is to reduce the polluting effect produced by discharge on a natural watercourse, where the prime considerations are normally those of dissolved oxygen, suspended matter and toxic materials. The reduction in the numbers of bacteria and pathogenic organisms is normally coincidental, and although more than 90 per cent may be removed from the crude sewage by conventional treatment, the quantities originally present are so vast that the treated effluent may still contain a very large number, as might a river containing a high proportion of effluent discharging to the sea. Thus, to achieve adequate dilution of bacteria, the effluent must be discharged through a pipeline that takes the sewage some distance out to sea.

250 A very few submissions of evidence advocate chlorination of disintegrated sewage which may be achieved either by injection of gaseous chlorine or, in the case of one proprietary process, by chlorine generated electrolytically. In assessing the relative merits of alternative methods of disposal and schemes involving chlorination, it must be borne in mind that chlorination does not of itself deal with the problem of visible contamination and in most cases a pipeline would be needed to reduce this to an acceptable level near the beach. A more important consideration is that chlorination is aimed at protecting the bather by killing all the pathogens, but owing to the rapidity with which the chlorine is taken up by organic matter it can only be effective on well-settled or filtered sewages. Even then there is a risk that chloramines formed by the process will be harmful to marine life adjacent to the outfall.

251 As an alternative to full treatment or chlorination, crude sewage can be discharged through properly sited outfalls with diffusers after screening and comminution of gross solids. The process of screening and comminution of solids is imperative since otherwise some of the offensive solid matter discharged from an outfall tends to float, and for any economic outfall length there is a distinct risk of this material being carried back to the shore during periods of strong onshore winds. If however this material is removed or disintegrated and diffused, the situation is entirely different as the finely-divided material will be more widely dispersed and diluted and will be disinfected by the sea and sunlight. In a well designed outfall scheme we are satisfied, on the basis of the information available to us, that dangers of beach pollution can be largely, if not completely, eliminated. Such a scheme is often easier and cheaper than the construction of a conventional treatment works. It avoids the considerable problems of locating a works in a coastal area, the disposal of sludge, and the cost of operating the works.

252 In recent years there has been a noteworthy development in the method of laying outfall pipes into the ocean which has made this method of sewage disposal an economic proposition. Whereas ten or fifteen years ago an outfall a quarter of a mile in length was considered long and costly, it is now feasible, either by floating out a pipe or by pulling it to sea from anchored craft, to lay an outfall of much greater length up to two or even three miles from the shore at costs which are not prohibitive. There is therefore a tendency nowadays in large coastal resorts, to give serious consideration to this method of disposal.

253 Unfortunately, it is easier to specify the need for a 'properly sited outfall' than to define one. What is suitable is a function of a large number of variables, and can only be decided in any particular case by reference to all the relevant local factors, which, in the sea, vary in complicated ways. The variables include the gradient and contours of the sea bed; the mean rise and fall of tides; the strength, direction and duration of the tidal streams; the direction, force and prevalence of winds; the contour of the shore line; the distribution and density of the population; whether or not there are amenity beaches or fisheries in the vicinity; and, importantly, the quantity and nature of the sewage to be discharged.

254 To determine the effects of these variables it is necessary to undertake extensive tests. It is clear that mere float tests are not sufficient alone, since floats are readily wind-driven and do not indicate the concentration of the pollution. What is additionally required is dye and/or radioactive tracer tests, together, if necessary, with a hydrographic model. In the light of these tests the proper design of an outfall can be determined, bearing in mind that what might be acceptable in an inaccessible place, with deep water and strong tides, would be quite impermissible in shallow water off amenity beaches. Where these are close by, or in waters used extensively for sailing and water-skiing, even more stringent precautions are necessary.

255 The general principles which should be applied to the particular circumstances are that all crude sewage should be screened and comminuted before discharge from diffusers on long outfalls. Whilst it is impossible to specify what is meant by a long outfall, it is relevant to notice the valuable and detailed work done by the Water Pollution Research Laboratory on this question[2]. They suggest that for relatively small outfalls, that is from less than 10,000 population, an outfall of about 400 yd (400 m) beyond low water mark is generally sufficient. Such a length, however, would not be sufficient for outfalls from larger populations, nor in shallow water, and lengths of two or three miles or even longer may be required. As we have made clear above, the length of an outfall is only one factor in the design.

256 In some areas, the need to avoid or minimise harm to fisheries will affect the choice of site for an outfall and the extent of treatment given to sewage before discharge. When satisfactory sites for outfalls have been located, additional protection can be given by timing discharges according to the tides.

257 If these precautions are taken the results should be satisfactory so far as our present knowledge goes, reducing any slight risks to public health which may exist at present and avoiding damage to amenities and fisheries. Where, because of difficult ground conditions, installation of a long pipeline would be exceptionally expensive, or where discharges from it would seriously harm fisheries, it may be preferable to construct a conventional treatment works or use chlorination or other means of reducing bacteria such as ozonisation or lagooning, accompanied by removal of solids.

Industrial discharges

258 The objective of controlling discharges of industrial waste to the sea is to achieve a dilution and dispersal of any toxic substances so that little or no harm is done to marine life. The requirements to achieve this depend on the toxicity and amount of the substances to be discharged and the local topography and water movements. It may also depend on the proximity of important fisheries or fish nursery grounds.

259 In many cases, where toxicities are low the desirable dilution and dispersal are achieved by discharging at low water spring tides but in other cases longer outfalls and diffusers or pre-treatment may be required.

Control of coastal discharges and dumping

260 The eleven Sea Fisheries Committees around the coast of England and Wales have no powers to control discharges by local authorities but they have bye-laws prohibiting or regulating other deposit or discharge, within the three-mile limit, of any solid or liquid substance detrimental to sea fish or sea fishing. Nine of these committees require consents before discharges can be made and six require these consents to be confirmed by the Minister of Agriculture, Fisheries and Food. As only the Lancashire and Western Joint Sea Fisheries Committee has its own pollution staff and laboratory facilities, the committees rely to a considerable extent on technical advice from the Ministry of Agriculture, Fisheries and Food's Marine Pollution Research Unit at Burnham-on-Crouch, Essex. This unit does basic research on marine pollution, has a continuous programme of toxicity testing, and carries out special investigations, for instance in connection with industrial discharges.

261 Local authorities have to obtain the sanction of the Minister of Housing and Local Government or the Secretary of State for Wales for loans required for capital expenditure on schemes for sewage disposal. New schemes for coastal discharges, when the proposed expenditure is at least £100,000 or the product of 2·4d rate in the £1, whichever is higher, are carefully scrutinised by an Engineering Inspector and a public local enquiry or local investigation is generally held. Loan sanction is not given unless a scheme avoids risk to public health and amenity. At present float tests are normally required to determine whether the position of an outfall will meet these requirements.

262 As there are at present no controls over coastal discharges in the interests of public health and amenity, there is no systematic surveillance of sewage disposal arrangements in coastal areas generally. However the Engineering Inspectors make a few visits every year to places where beach pollution is suspected, which are followed as necessary by discussions on any improvements required in methods of sewage disposal to the sea. These discussions do not always result in action.

263 The Public Health Laboratory Service Committee Report on Sewage Contamination of Bathing Beaches in England and Wales[1] concluded that, with the exception of the few aesthetically revolting beaches, the risk to health from bathing in sewage-contaminated sea-water could, for all practical purposes, be ignored. We have found that aesthetically revolting conditions on beaches continue to occur and remain a risk to public health. We have also found that in some seaside places where sewage solids are not obvious on the beaches, crude sewage is discharged so close to the shore that in some conditions there is insufficient dilution to avoid unpleasant contamination of bathing waters

and the possibility of infection to bathers and damage to marine life.

264 We are therefore recommending that all coastal discharges should be controlled because a potential risk to public health exists in the grossly polluted places and there is, to put it mildly, a diminution of pleasure. We are also recommending control of dumping as it might have long-term effects on marine conditions.

265 There are a number of substances which we consider too toxic to be discharged in large quantities to coastal waters or to be dumped on the nearest spoil ground. These substances include cyanides, arsenicals, heavy metals, and the more toxic and persistent organic substances.

266 The limits of territorial waters have no significance in terms of the suitability of a particular area for dumping. At present there is no statutory control of dumping beyond the three-mile limit although most companies wishing to dispose of very toxic substances at sea seek the advice of the Ministry of Agriculture, Fisheries and Food (who consult the Board of Trade) with regard to appropriate dumping areas. While some dumping is permitted on some of the spoil grounds on the continental shelf where there is little fishing, it is recommended that the more toxic substances should be dumped in very deep water off the continental shelf west of the United Kingdom.

267 Dumping in deep water by all European countries has been increasing and there is now uncertainty about the long-term effects of highly toxic and persistent substances deposited in the sea. Even if the present voluntary scheme covers most dumping and has been working satisfactorily, the time has now come when control should not be left to a voluntary scheme. Both national and international monitoring and control, based on expert knowledge, are now required. Close co-operation is required between the authorities responsible for controlling discharges and dumping within and beyond the three-mile limit, to ensure no anomalies arise from the presence of this dividing line.

268 We have carefully considered what authority should be responsible for the wider measure of control that we now consider necessary. The Sea Fisheries Committees have already been controlling industrial discharges, to avoid harm to sea fisheries, and have knowledge and experience of marine conditions. However, with one exception, the Committees do not have technical staff or laboratory facilities and they are not constituted to be responsible for amenity or health. It would therefore be necessary to extend the powers of the Sea Fisheries Committees or river authorities, or to give a new organisation these powers. We consider that, with their long and wide experience of pollution control and their extensive technical facilities, the best solution will be to extend the powers of the river authorities to the control of all discharges by pipe-line, and dumping out to the three-mile limit, with the object of safeguarding public health, amenity and fisheries.

269 The river authorities will have to be retitled and reconstituted to perform these new functions. Their staffs will need to be supplemented to include people with a knowledge of the marine environment and marine fisheries. They should include among their members people who can speak for the inshore fishing industry and other users of coastal waters.

270 The same form of control should be used as in the Rivers (Prevention of Pollution) Acts. Licences for any discharges would be required, and the new authorities should have the power to attach conditions to them. In order to safeguard marine fisheries, while the necessary experience is being gained, we recommend that no consents should be issued by the authorities without reference to the Ministry of Agriculture, Fisheries and Food. All existing discharges should come within the consent scheme, though it will be necessary to give some longstanding discharges adequate time to reach the required standards.

271 The methods of sewage disposal we propose will greatly improve any unsatisfactory conditions at the seaside and reduce any hazards to health from coastal discharges of sewage so that the risks of infection to bathers from sewage, already much less than from the other means of transmission of infection in the community, will be even further reduced. We are not recommending that all sewage should have full conventional treatment before discharge to the sea because the cost, which might be about £100 million more than our proposals, would not be worth the benefit. We realize that all public expenditure should be subject to a cost/benefit analysis. Our terms of reference require us to have regard to the economic aspects of sewage disposal. We are not able to ask for priority for expenditure of so large a sum to multiply round our coasts full conventional treatment works. If sewage is dealt with as recommended in paragraphs 254 and 255 and is sufficiently diluted by the sea, it rapidly becomes oxidised by natural processes and it need be neither noticeable nor, as far as we know, harmful.

272 The introduction of control of coastal discharges to the sea will add considerably to the cost of sewage disposal in England and Wales. In 1967 and 1968, five schemes were passed for sewage outfalls from one to three miles long, to serve a total resident population of about 400,000, which would be multiplied by summer visitors. The total cost of these schemes amounted to about £4,400,000, or £11 per head of resident population. The additional rate in the £1 ranged from 6d to 1s 10d. As there is no evaluation of all the existing methods of discharge from a resident population of about 6 million, we cannot estimate how much our recommendations will cost, but on the above costs for recent schemes which appear to meet our criteria, the cost per million resident population would be about £11 million, and the cost of industrial discharges could also increase considerably. We are however only recommending methods of discharge which are already employed by many local sewage disposal authorities and industries, to their credit. Expenditure is justified to bring all areas with unsatisfactory methods of discharge up to the satisfactory standards already achieved in some areas.

Recommendations

273 River authorities should be reconstituted and renamed and given the necessary legal powers to control discharges to the sea within the three-mile limit. The existing responsibilities of the Sea Fisheries Committees to protect fish or shellfish from harm due to discharged or dumped waste material should be transferred to the new authorities. (Paragraphs 268 and 269).

274 The staff of the new authorities will need to include people with a knowledge of the marine environment and marine fisheries, together with people who can speak for the inshore fishing industry and other users of coastal waters. (Paragraph 269).

275 All existing and new discharges must require consents from the new authorities, though it will be necessary to allow adequate time for discharges to reach the required standard. No consents should be issued without reference to the Ministry of Agriculture, Fisheries and Food until the new authorities have the necessary expertise. (Paragraph 270).

276 Crude sewage should only be discharged after screening, comminution and through diffusers on long outfalls, when the siting has been determined after a comprehensive study of local factors. (Paragraphs 253–257).

277 The new authorities should be given power to control all discharges by pipe-line; and dumping within the three-mile limit. (Paragraph 268).

278 The central government should be given statutory powers to control the dumping of waste beyond the three-mile limit. This control should apply to British ships or ships using British ports. (Paragraph 267).

References

[1] Sewage Contamination of Coastal Bathing Waters in England and Wales. J. Hyg., Camb., 1959, **57**, 435.

See also:—

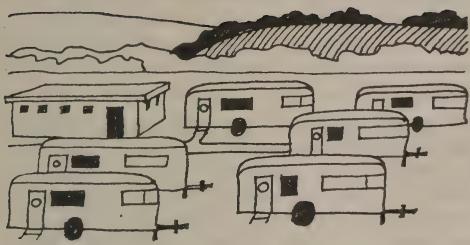
Sewage Contamination of Bathing Beaches in England and Wales. Medical Research Council Memorandum No. 37 HMSO, London, 1959.

[2] Pike, E. B., and Gameson, A. L. H. Wat. Pollut. Control, 1970, **69**, (4), 355.

279 The effects of dumping sludge and toxic and persistent substances to the sea should be monitored and more research be put in hand to determine the fate of such materials and their effect on marine life in order to assess the extent to which they may be deposited without having adverse effects on fisheries. (Paragraphs 60 and 267).

280 The Government should support the formulation of international agreements to control sea pollution. (Paragraph 267).

Chapter 6 Sewage Disposal to the land



Sewage disposal from houses without main drainage

281 There is no precise information about the number of houses which are not on main drainage, but there are probably about 1,200,000, with about 3 million people living in them. The 1966 Census showed that 270,000 dwellings were without WCs; many houses with WCs drain to cesspools or septic tanks, particularly in rural areas.

282 Earth and pail closets can be sources of infection to the members of the household using them and can also cause a more general risk of fly nuisance. Their contents may be buried in the garden (see Plates 4 and 5) or collected by the local sewerage authority. Either operation is obviously unpleasant, and a hardship to the elderly. Evidence records many examples of local repugnance to pail closets; for example, the inhabitants of a village were "disgusted by buckets being emptied (into lorries) in Blackberry Lane at lunch-time" (evidence from the National Federation of Women's Institutes). Sewer ditches can also be objectionable.

283 The evidence from all the organisations concerned with rural conditions was in favour of the speedy replacement of earth and pail closets, and we do not think that anyone would disagree. Evidence has also shown that there are places with septic tanks or cesspools where improvements are also greatly needed.

284 Cesspools and septic tanks are capable of operating hygienically and conveniently, but risks to health can occur if overflows from them pervade surrounding land, ditches or streams, particularly when near houses or places where people pass or children play. When the soil is impervious, the land low lying or 'sewage sick', the overflows may remain in pools on the surface.

285 The increasing use of water, especially when rural homes are modernised and bathrooms and WCs are installed, means that existing cesspools require increasingly frequent emptying, while the capacity of septic tanks may cease to be adequate for even the limited amount of treatment they provide. Cesspools may be emptied either by a local authority or by private arrangement. Some local authorities charge for the service, others provide a free but infrequent emptying service. When a householder has to pay, there is naturally a tendency to put off the emptying too long. Overflows then occur, which may cause public nuisance or risk to health. We consider that the local authority should be responsible for cesspool emptying. As everyone pays rates, whether their houses are connected to main drainage or not, it seems only fair that the local authority should provide a free and adequate service for cesspool emptying and septic tank clearance.

286 Many people do not understand that septic tanks operate by the biological anaerobic digestion of the organic matter, and householders often wrongly attempt to sterilise them by disinfectant or expect them to be completely void when cleared out. More information should be available to householders about their management. But the main causes of unsatisfactory operation of septic tanks are probably defective design, inadequate size or lack of repair. When the owners of septic tanks, like the owners of cesspools, have to pay rates, and especially if they hope to be connected to the main drains, they are naturally unwilling to spend large sums to replace or repair defective tanks.

287 In the past, overflows from cesspools and septic tanks have been the source of a number of outbreaks of disease, one of the worst occurring in Bournemouth in 1936. This was a milk-borne outbreak of typhoid fever (718 cases), originating on a single farm where the cattle were believed to have been either infected or contaminated from a stream. The stream contained typhoid bacteria derived from a discharge higher up on its course, which came from a house where a chronic carrier of the disease was resident[1].

288 Similar discharges have led in the past to the contamination of drinking water supplies with resulting outbreaks of disease. While large-scale outbreaks are now unlikely owing to the improved hygiene of milk production and the chlorination of public water supplies, there is still the potential danger of sporadic cases among the public or infection within the household should a carrier be resident in a house with a defective septic tank or overflowing cesspool. Fortunately in England and Wales there has been no general infection, as far as is known, from such a source recently, but people who live near polluted land or ditches are very conscious of the danger of infection. Similarly, the possibility of overflow forces many people with inadequate cesspools or septic tanks to be niggardly with the use of water, although nearly everyone now has abundant supply from the mains.

289 Progress in bringing rural sewerage up to urban standards has been considerable since the end of the last war, and expenditure is now running at about £20 million a year. Sewering small scattered communities can be very expensive and a scheme may cost up to £1,000 per house for the sewers and a new sewage disposal works, though the average cost is £500 per house. Under the Rural Water Supplies and Sewerage Acts 1944–65 grants are paid for sewerage (ie for sewers, not for sewage disposal works) in rural areas only when they have not previously had main drainage. There are no grants available for replacement of main drains, although this can be very expensive in rural areas. The Exchequer grant to the council is 35 per cent of the cost per property served the first time (maximum £500) less £40. The county councils usually make a similar grant, and most rural district councils receive the rate resources element of the rate support grant which helps to pay for, and often meets a high proportion of, the annual running costs and the debt charges on that part of the capital cost which is not met by the specific first-time rural sewerage grant. Despite these grants the cost has deterred many rural district councils from undertaking schemes where conditions are patently unsatisfactory, though some rural districts have had the resources and vigour to go ahead with a comprehensive programme for all the houses which can reasonably be connected to main drains.

290 Progress in improving rural sewerage has been checked by the general restrictions on public expenditure imposed during economic crises. When the economic situation has required curtailment of public expenditure, it is rural sewerage which has mostly been deferred on the sewege account, because deficiences in urban sewerage could have more serious consequences. Thus there has often been a time lag between the provisions of mains water and of main drainage. The total value of schemes, mainly for rural sewerage, which stood deferred in November 1969 by the Ministry of Housing and Local Government for England was £10 million (220 schemes) and by the Secretary of State for Wales was £4 million (60 schemes).

291 We do not consider that such checks to the extension of rural sewerage are consistent with the policy of improving conditions in obsolete housing, a policy which was reinforced by the Housing Act 1969. Main drainage is by itself a great improvement when methods of sewage disposal are primitive or working unsatisfactorily. We recognise that laying sewers to isolated properties would be too expensive, but in other cases schemes to replace earth or pail closets, or badly working cesspools or septic tanks, should go ahead. At an average of £500 per property for sewerage and sewage disposal, the cost is high, but the considerable amount of rural sewerage recently undertaken shows that the benefits are recognised as justifying the cost.

292 Another check to the replacement of unsatisfactory sanitation, particularly in rural areas, has been the cost to houseowners. There are grants from public funds available for meeting half the cost of replacing earth or pail closets either under the Public Health Act 1936 or under the Housing Act 1969. The local authority can also lend the owner his share of the expenditure. Many owners and tenants are however too poor to be able to afford the expenditure, and sometimes also too elderly to consider the benefit worth the expenditure for their few remaining years. A local authority can pay for a house's connection to a new sewer but usually the houseowner has to meet this charge, which varies according to the distance from the sewer. Thus when main drainage is installed it is not uncommon for some houses with unsatisfactory means of sewage disposal not to be connected. In the interests of bringing homes up to modern standards we think that house connections to a new sewer should be made at the local authority's expense.

Sewage disposal direct to the land

293 Land is fouled when the sewers, or sewage disposal works, are so over loaded that the sewers are surcharged and raw sewage escapes through manholes and inspection chambers, and floods roads, gardens and even houses. After floods, faecal matter from untreated storm overflows may be deposited on land.

294 Where there is a definite risk to public health from these causes there are usually schemes for improvement, though they sometimes proceed very slowly. Sometimes local authorities have not planned far enough ahead. Sometimes expense has deterred a local authority from deciding to install the drains and sewage treatment required for the increasing flow of sewage, or to replace defective installations, until a crisis has occurred.

295 Sewage from travellers on railways is discharged straight on to the railway tracks. There is no proof that this method of discharge is a hazard to health but it is obviously preferable to use different methods. The present conditions are most unpleasant for workers on the tracks. We are glad to hear from the British Railways Board that chemical closets will be included in the new design of passenger coaches which will be produced in two to three years time and that there is an experiment at Euston Station in the use of an "Effluent Flushing Apron" for sleeping cars at stations, which will avoid discharge to the tracks.

296 The fouling of fields alongside roads is objectionable and may cause disease to farm animals. It will get worse as the use of cars increases until more public lavatories are provided at the road side. There is a Ministry of Transport and Ministry of Housing and Local Government pilot scheme to assist local authorities to build public lavatories by main roads in rural areas.

297 Campers and caravanners on recognised sites now expect water flush lavatories, according to the evidence of the Camping Club of Great Britain and Ireland. These generally discharge to septic tanks, but some local authorities require the installation of sewage treatment plants and this increases the cost of sanitation considerably. We think that people enjoying recreation in the countryside must be prepared to pay the cost of avoiding pollution on the land, as they are evidently prepared to pay for avoiding the discomforts of primitive forms of camping and caravanning.

298 The use of private chemical lavatories among campers and caravanners is on the increase. The disposal of their contents can cause problems if they are emptied into septic tank systems. Special disposal points for chemical closets are needed and are now often provided on camping and caravan sites.

Discharges affecting underground water

299 About a third of the public water supply is drawn from underground water, which is usually pure and free from bacteria when taken from a deep well. It is not therefore normally given full treatment by water supply undertakings but, in case it might contain bacteria, it is chlorinated and, when necessary, treated by filtration before it is used for public supply.

300 Pollution of underground sources of water could be more serious than river pollution, because it could be more

concentrated and persistent and less easily noticed or traced, and because, unlike river water, underground water is not normally fully treated before use for public supply.

301 In case seepage from tips of solid or semi-solid toxic wastes might contaminate water sources, the Minister of Housing and Local Government and the Secretary of State for Scotland appointed a technical committee in 1964, to advise whether changes in disposal or control arrangements were required. The Committee will be reporting shortly.

302 Pollution of underground water by liquid wastes fortunately does not appear to be common but the evidence presented to us shows that it does occur. Chronic sewage pollution of wells may occur from the surface through fissured strata, for example by swallow holes or from leaking drains, cesspools and septic tanks. Extra care is needed in the treatment of these waters by chlorination and possibly filtration. In some cases the well water may need full treatment.

303 Where heavy industry is sited on permeable strata over aquifers there is a continuous risk of pollution of groundwater. In one such area industrial boreholes have had to be abandoned because water-gas tar passed into the ground from gasworks. Nearby, the leakage of many tons of petrol from a fractured pipe grossly contaminated the water in the gravel strata. Other oil leaks have caused or threatened contamination of groundwater.

304 Occasional or accidental discharges are also responsible for some pollution of underground sources of water. Cases quoted include the unauthorised discharge of phenolic and resinous material into a disused well, apparently causing a bad smell and taste in the water from a well a mile away; the pollution of wells near a river after flooding by contaminated river water and by trade effluent; the run-off from pea-haulm wastes and the seepage of silage liquor which contaminated water sources; and chrome waste deposited in a limestone quarry which polluted water supply half a mile away.

305 It is many years since infectious disease was caused in this country by pollution of wells by sewage, eg typhoid fever from sewage pollution of a Malton well in 1932. But large-scale infection from such occurrences has been reported in the USA quite recently, so the continuous vigilance shown by the authorities is absolutely necessary.

306 A high level of nitrates occur in a few underground sources used for public supply. Nitrates are derived from the ultimate oxidation of nitrogenous organic and vegetable matter in the soil, and from agricultural fertilisers applied to the ground in the catchment area of the well. In one case quoted in evidence the water undertaking suspected that the cause was the discharge of crude sewage from a local authority works nearby. Excessive nitrate in water can cause the rare condition of methaemoglobinaemia of infants. In 1951–4 in Britain four cases were reported, including one death, of infants affected in this way. The local well water drinking supply contained 72 mg/l of nitrate nitrogen. The World Health Organization International Standard for Drinking Water recommended a limit of 10·2 mg/l of nitrate nitrogen, but in the British climate, where less water is consumed than in warmer countries, we understand that a higher acceptable level of up to 22·6 mg/l is recommended in a new edition of the World Health Organization's European Standards for Drinking Water. So far as we are aware, there have been no cases of anoxia of infants due to nitrates in the water supply in this country in the past fifteen years. The situation is being carefully watched by the health authorities. For example, Medical Officers of Health in East Anglia have asked health visitors to supervise carefully infants at risk and make bottled water of low or nil nitrate content available to them.

307 The powers available to river authorities under section 72 of the Water Resources Act to prevent pollution of underground water are limited to discharges of industrial or sewage effluent made to underground strata by means of well, borehole or pipe. We agree with the Association of River Authorities that this power is far too restricted, as most groundwater pollution is caused by the use of land for the disposal of solid or liquid wastes, from which polluting water percolates through fissures in the ground. Section 72 should be extended to include discharges to mineshafts, fissures in rocks, swallow holes or any other similar means of penetration into underground strata. This extension of Section 72 should however exclude the ordinary operations of good husbandry on farms unless the river authority has evidence that an operation is causing pollution of underground strata which is materially greater than the normal percolation from the surface of farm land. The control of percolation from toxic substances to aquifers, which is also necessary, should be considered following the report of the Committee on the Disposal of Solid Toxic Wastes.

Recommendations

Sewage disposal from houses without main drainage

308 There should be a positive policy to improve rural sanitation with priority for the replacement of earth and pail closets and the elimination of sewer ditches. (Paragraphs 281–292).

309 When a local authority provides a new main sewerage scheme all properties near the line of the sewer should be connected to the sewer at the local authority's expense (Paragraph 292).

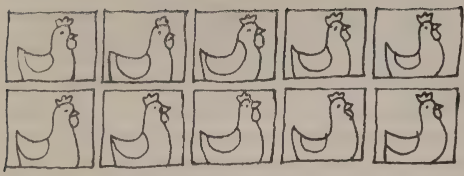
310 Local authorities should provide a free and sufficiently frequent cesspool and septic tank clearance service. (Paragraph 285).

Protection of underground water

311 Section 72 of the Water Resources Act 1963 should be amended to give river authorities more effective control of discharges to underground strata, without interfering with normal good husbandry on farms. (Paragraphs 299–307).

Reference

[1] Shaw, W. Vernon. Report on an outbreak of enteric fever in the County Borough of Bournemouth and in the Boroughs of Poole and Christchurch. Reports on Public Health and Medical Subjects, No. 81, HMSO, London, 1937.



Chapter 7 Effluent Disposal Problems in Industry and Agriculture

INDUSTRY

Industrial effluents

312 Industry uses large quantities of water for a variety of processes. For example, for the production and processing of one ton of coal up to 330 gal (1,500 l) of water are required; for one ton of paper 20,000 gal (90,000 l); for one ton of viscose staple fibre 30,000 gal (136,000 l); and for one ton of steel 45,000 gal (200,000 l). In the chemical industry consumption varies widely for each product, and one ton of a chemical produced may require up to 200,000 gal (900,000 l) of water. The waste waters produced by industry are termed 'trade' or 'industrial' effluents, and are discharged to local authority sewers, to watercourses or to the sea. Under existing legislation 'trade effluent' has been defined to include wastes from farms and from research or experimental establishments. Discharges to sewers are controlled under the Public Health (Drainage of Trade Premises) Act 1937 and the Public Health Act 1961 (Part V); to rivers under the Rivers (Prevention of Pollution) Acts 1951 and 1961; and certain discharges to estuaries under the Clean Rivers (Estuaries and Tidal Waters) Act 1960.

313 The procedure under each code of legislation is broadly similar and consists of an application by the intending discharger for permission to commence, or alter, the discharge. For discharges to sewers, application is made to the sewerage authority (usually the local authority) and for river or estuarine discharges to the river authority. On receiving applications authorities may either refuse their consent to the discharge, or may grant consent unconditionally, or (more usually) subject to conditions. The conditions which may be imposed are set out in the relevant legislation. In every case there is a right of appeal to the Minister of Housing and Local Government or to the Secretary of State for Wales against the decision of the authority. Sewerage authorities may, instead of operating the consent procedure, enter into an agreement with the trader as to the terms and conditions under which the industrial effluent may be accepted into the sewerage system.

314 More than two-thirds of all water abstracted in England and Wales is used for cooling purposes. This water is normally used once and discharged to a watercourse or to the sea at an elevated temperature, but otherwise relatively unpolluted. The increase in the temperature of river water which results from such discharges accelerates biological activity in the water, but provided the temperature does not exceed about 25°C (77°F), or in the case of the sea about 20°C (68°F), it does not generally give rise to adverse effects.

315 On average about half the flow of sewage received at local authorities' sewage works is composed of industrial effluent. In round figures this amounts each day to 1,500 mil gal (6·8 mil m^3), which with 1,600 mil gal (7·3 mil m^3) of domestic sewage, makes a combined total flow of 3,100 mil gal (14·1 mil m^3). In addition a considerable flow of industrial effluent is discharged directly to water courses or to the sea, either with or without prior treatment. Many of the unit processes used for the treatment of industrial effluents and sludges are similar to those used at sewage works and, in the majority of cases, it is customary to treat such effluents in admixture with domestic sewage at sewage works. The constituents of some industrial effluents however are toxic and can give rise to considerable problems in the biological processes employed in the treatment of sewage.

316 Industrial effluents have been broadly classified as follows[1]:

1. Effluents from food and drink manufacture. The main characteristics of these effluents is that the compounds they contain are natural organic compounds.
2. Other organic effluents. This class includes effluents from such industries as paper, leather and wool, in which the raw materials used are animal or vegetable matter.
3. Effluents containing metals and cyanides. These effluents are largely produced in the engineering industry.
4. Chemical effluents. The effluents arise largely from the chemical industry or those industries using chemicals.

Effluents in the first two classes do not normally present problems in the treatment of sewage provided adequate treatment capacity is available. Effluents in the third class can be toxic to fish and can inhibit biological processes used at sewage works. The final class may at one extreme include effluents containing relatively small quantities of complex organic compounds, such as some of the pesticides, which are highly toxic in very small concentrations; at the other extreme the effluents may be quite innocuous.

317 It is the toxic effluents which can give rise to the greatest problems. If discarded without sufficient care and attention they can lead directly to difficulties or even breakdowns at sewage treatment works and to fish deaths, while sub-lethal quantities may make water unsuitable as a source of potable supply. Discharge of excessive amounts of cyanide into sewerage systems can cause danger to men working in sewers.

318 To help in assessing the toxicity of effluents containing metals and other substances, the Water Pollution Research Laboratory has established an information service (abbreviated to 'INSTAB')[2] on toxicity and biodegradability (the degree to which substances are broken down by biological action). It has prepared an index, which is continually being added to and revised, of the effects of substances on fish toxicity and other factors important in effluents. This index is free on request. We consider this to be a very useful service and one which should be used to the full by both industry and those responsible for water pollution control.

319 Efficient control of trade effluents by local authorities and river authorities is essential if toxic materials are not to reach sewage works or rivers in sufficient concentrations to cause adverse effects. We find that with some industrial effluents the traditional criteria of biochemical oxygen demand (BOD) and suspended solids are not necessarily the most appropriate and indeed, in some cases, may be irrelevant. Cases in point are effluents containing known toxic constituents, when, where necessary, the amounts of these materials present in the discharge should be individually controlled, as is provided for under the appropriate legislation. During our enquiries we have been surprised to learn of the comparatively large number of cases where the provisions of the Public Health (Drainage of Trade Premises) legislation have either been ignored altogether by local authorities, or discharges permitted for which the available treatment facilities were or have become inadequate. We consider it imperative for local authorities to exercise effective trade effluent control, and that they should implement effectively the quality and quantity control provisions provided in the legislation.

320 We accept that in some cases the offending toxic constituents cannot be identified by normal analytical techniques and it is not therefore always possible to apply limits to control individual materials. We are pleased to note that a number of biological tests using a variety of aquatic species have been devised which give an indication of the toxicity of polluting substances that may be present; it is thought that biological techniques of this kind will become of increasing value. To meet special situations a standard fish toxicity test has recently been recommended[3] for use in consent conditions, and we hope that this will prove of value.

321 New compounds are continually being used and developed by industry and there is always the risk that some of the residues or wastes from them may give rise to problems in effluent disposal. We consider that close co-operation between manufacturers and sewage disposal authorities is needed so that they may be aware of each others problems with a view to minimising the possibility of such risks. With many industries, we feel that insufficient attention is paid to reducing the quantity of effluent produced, and to the removal and recovery of certain constituents from effluents before discharge. By adopting 'good housekeeping' methods benefits to both parties—the manufacturer and the sewage disposal authority—could result. The manufacturer would save on trade effluent charges, on the costs of water supplied and on materials recovered for re-use, and the sewage authority on reduced treatment demand. The co-operation suggested might help to bring this about.

322 Similarly, river authorities are vitally concerned about some synthetic organic compounds, which may be discharged via sewage works producing otherwise satisfactory effluents. Such chemicals put in jeopardy water supplies abstracted from rivers. In our view river authorities (or their successors) should be included as "interested parties" under the Public Health (Drainage of Trade Premises) Acts, so that they are consulted by local authorities before new discharges of trade effluents are made to sewers.

323 We recognise that, if controls are to be strictly enforced, more qualified trade effluent inspectors, chemists and analytical services will be required. We have sympathy with the suggestion submitted in evidence to us, that to help the smaller local authorities as at present organised, and also the smaller industrial concerns, the Government should set up a consulting service on a self-supporting financial basis to operate nationally and provide the technical, and where necessary the financial and legal, expertise. Such services should be available on request to any appropriate body prepared to pay the fees to deal with any problem connected with the reception and treatment of sewage and industrial effluents.

Deficiencies in legislation

324 Certain deficiencies in the trade effluent legislation have been brought to our attention. Section 10 of the Public Health (Drainage of Trade Premises) Act 1937 permits the taking of samples of trade effluent only as it passes, or has passed, into a public sewer. If there is a length of private sewer serving a number of industrial premises it becomes virtually impossible to identify the source of any illegal discharge. We agree with the Rural District Councils Association that the power to sample only at the discharge into a public sewer is unduly restrictive. We consider that local authorities should be empowered to sample and require the provision of sampling points on private sewers from trade premises, subject to the same safeguards about reasonable terms of access and confidentiality of information gained as contained in the existing legislation.

325 Some trade effluents are wholly exempted from control by legislation. Trade effluents discharged under a pre-1937 agreement are protected by section 7(4) of the Public Health (Drainage of Trade Premises) Act 1937. These agreements have now run for over 30 years (and in some cases very much longer) and we see no justification for continuing them after such a long time. Other manufacturers are entitled by 'prescriptive rights' to discharge the same volume as in 1937, provided the effluent has not changed since then. In many cases there are difficulties in establishing what was actually discharged in 1937, due to lack of records. These prescriptive rights have probably brought greater advantages to the discharger than was originally intended.

326 Laundries were originally exempted from the controls of the trade effluents legislation because the argument that their process was merely a substitute for domestic clothes washing was accepted. Many laundries, however, wash materials used in industry, and now they frequently undertake dry cleaning. There are other industrial processes which are a substitute for domestic work (eg food processing) and are subject to trade effluent legislation. The volume of discharge from laundries is such that they should also be brought under control.

327 The effluent from Crown properties is not subject to the control of legislation though Crown properties are expected to conform to the requirements of the sewage disposal and river authorities. When there is repeated failure to comply with the standards required by the authorities, the latter have no powers to remedy the situation. The volume of effluent from Crown properties can be considerable, for example some hospitals and RAF

stations can have discharges up to half a million gallons a day. One hospital we know of discharges 1 ton of swill per week. We therefore recommend that a direction be given to Crown properties to comply strictly with the requirements of the authorities.

328 A number of trade effluent agreements entered into after the 1937 Act do not appear to provide for their determination. When an agreement is to be negotiated to regulate the discharge of trade effluent into public sewers, we consider there is a need for the use of a form of agreement providing for determination and review. We note that a model agreement which covers payments per 1,000 gallons discharged has been drawn up by the Joint Advisory Panel of Local Authority Associations and the Confederation of British Industry.

Disposal at sea

329 England and Wales have a long coastline in comparison with their land area and consequently much greater opportunities than many other industrial countries for discharging effluent to the sea and estuaries rather than to rivers. Marine disposal of untreated trade effluents from inland factories by pipelines has been considered seriously on several occasions during the past decade. We understand that there are strong possibilities that some systems may be built in the 1970's. We do not think the development of such systems should be resisted, provided discharges are controlled as we have recommended in Chapter 5 (paragraph 277) and consideration is given at the planning stage to the nature of the effluent, dilution and dispersal factors, and the effect on marine flora and fauna.

330 Effluent pipelines are classified as drains or sewers and thus are not subject to the Pipelines Act 1962. We consider that their construction would be facilitated if the Act could be amended so as to extend to effluent or sludge pipelines the same provisions for cross-country constructions as now apply to oil and gas pipelines.

Accidental spillages

331 Accidental pollution of surface and groundwaters can arise from road or industrial accidents resulting in a spillage of toxic material. Toxic substances released in an accident are generally swilled away into the nearest drainage system or watercourse, or they may seep into the ground and eventually reach the groundwater. It has been made clear to us that these hazards are of particular and increasing concern to the water-supply industry, which may have difficulty in detecting such substances and diverting them away from water intakes.

332 Consultative arrangements between fire brigades and river authorities exist, and we hope that these arrangements can be extended and strengthened where necessary to include water undertakers' interests. We note that the United Kingdom is a contracting party to the European Agreement concerning the International Carriage of Dangerous Goods by Road (the ADR agreement). We understand that various sub-committees of the Standing Advisory Committee of Dangerous Substances are, within the framework of the International Agreement, preparing proposals for regulations governing the construction, use and labelling of vehicles used for the conveyance of dangerous substances by road. We hope that these regulations will have considerable incidental benefits for the protection of water from road accidents involving corrosive and poisonous substances.

333 We have already referred in Chapter 3 to the risk of pollution from fixed installations, such as oil storage tanks, sited on or near river banks. We agree with the suggestion of the Greater London Council that there is a need for new legislation to provide safeguards against pollution from the storage of oil and other toxic substances. It is also necessary to ensure that those who transport, store or use oil or toxic substances should be responsible for any pollution of rivers, underground waters and sewers that may arise from accidental spillages, particularly those resulting from carelessness or negligence. At present river authorities are powerless to take action because, under section 2 of the Rivers (Prevention of Pollution) Act 1951, it must be proved that the pollution was knowingly permitted. We therefore recommend that this section should be amended to make accidental pollution an absolute offence, with substantial penalties.

334 We are also concerned at the unauthorised practice of transporting industrial wastes, which are presumably not acceptable to the river or sewerage authority in the locality of origin, from inland areas to coastal towns for discharge via sewers to the sea. There are also instances of 'fly tipping' of liquid industrial wastes into sewerage systems and into streams. Although it is an offence under existing legislation to discharge into sewers substances which are likely to injure them, to affect sewage treatment processes, or to be prejudicial to health, it is difficult to detect and stop illegal practices. Similarly 'fly' discharges to streams are difficult to detect and stop and can be very damaging. We hope that consideration may be given to the need for further control of toxic wastes and for the development of a toxic waste disposal service, when the report of the Technical Committee on the Disposal of Solid Toxic Wastes is received.

AGRICULTURE

Animal wastes

335 When animals range freely in the open, and farms comparatively isolated, the pollution of streams by animals and farm wastes is not a serious problem. In recent years however the problem has become serious owing to more intensive production, indoor housing, and demands for higher standards of hygiene in dairies. Modern techniques permit, and economics demand, the design and operation of large animal units, often on an intensive basis. During the period 1946 to 1968, the total number of cattle and calves in Britain rose from 9·6 to 12·2 million, pigs from 2·0 to 7·4 million, poultry from 67·0 to 127·5 million and sheep from 20·4 to 28·0 million. Over the same period the area of agricultural land fell by 300,000 acres (120,000 hectares). We appreciate that not all of these increases in numbers of animals may be due to intensive farming. Cattle, however, are now mostly kept in farm buildings during the worst of the winter and cows are taken indoors daily throughout the year for milking. The economics of pig and poultry production have led to predominantly indoor managements, while sheep are still kept usually outdoors.

Statutory controls

336 The disposal of farm waste is covered by the Public Health Act 1936, under which local authorities may deal with public nuisance by serving an Abatement Notice; by the Rivers (Prevention of Pollution) Acts 1951 and 1961, which make it unlawful to discharge trade effluent into a stream without the consent of the river authority; by the Public Health Act 1961, which brought farm drainage within the meaning of trade waste; and by the Water Resources Act 1963 which gives power to river authorities to control the pollution of underground water. The Rivers

(Prevention of Pollution) Act 1961 made it unlawful for farmers, like everyone else, to continue to make a discharge of trade or sewage effluent to a stream without having obtained the consent of the river authority. River authorities are now examining existing farm discharges more closely than in the past and are increasingly attaching conditions to their consents or refusing consent. The discharge of untreated farm effluents to watercourses should become increasingly unacceptable in future. Application for consent for any new or increased discharge must also be made to the river authority, and failure to do so render the offender liable to prosecution. We suggest that the Ministry of Agriculture, Fisheries and Food should remind all applicants for grant aid on buildings of these requirements. The enforcement of the Milk and Dairies Regulations has caused dairy farms to get rid of washing-down liquids and sterilising agents by a proper drainage system. The effluent can present difficulties in sewage treatment works or in watercourses.

Nature of the problem

337 Problems concerned with the disposal of farm waste have been emphasised in this country in the past five years and are similar to those arising in Europe and the Americas. The basic need is to find cheaper methods of dealing with manure and other wastes from large concentrations of animals. There is a wide variety of animal wastes, but many cause only local problems. The main product with which we are concerned is animal excreta. It has been estimated that livestock in the British Isles produce some 120 million tons of excreta per annum, consisiderably more than that produced by the human population. Fortunately, two-thirds of this total is produced by ranging animals and presents no particular problems to health or amenity. Furthermore, there are some 30 million acres (12 million hectares) of cultivated land on which manure can be spread, which means that it can be disposed of at the rate of 4 tons per acre (10 tonnes per hectare) per annum, a level which would produce no problems.

338 Animal manures have a significant fertiliser value as illustrated in Table 5.

Table 5 Nutrients per ton of Fresh Manure

	Total Units*			Available Units			Current Value		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	£	s	d
Poultry	42	40	26	28	20	20	2	0	8
Cows	12	6	12	8	3	9		11	3
Pigs	12	12	8	8	6	6		11	11

*Units expressed as 1 per cent of 1 cwt (51 kg).

The current values shown are the equivalent of replacing these available nutrients with artificial fertiliser, though not all nutrients are immediately available to plants. In addition to their fertilising value solid manures have a beneficial effect on soil structure.

339 Large animal units tend to be concentrated in certain parts of the country and we can no longer assume that there is an even distribution of manure over a large acreage of land. Individual units, particularly pig and poultry enterprises, may have insufficient land of their own for the disposal of their wastes. Consequently these either have to be transported elsewhere or treated on the site. In general it is most advantageous to handle these wastes as a solid, but economic considerations, particularly the cost of labour, have led to the introduction of mechanical methods of manure disposal. Often these involve the dilution of excreta with water to form slurry, which can then be pumped or taken by tanker on to land. Slurry is basically different from solid farmyard manure. It creates a greater smell, it cannot be stacked or stored so easily, and because it is not normally subjected to a composting process, microorganisms are not so readily destroyed[4].

Disposal on land and its limitations

340 Many of our soils are heavy clays with poor natural drainage and they tend to retain a high moisture content in most seasons. Application of slurries to such land has to be limited because of the possibility of run-off. It may also effect soil structure. Access for vehicles may become difficult or impossible at certain times of the year.

341 The distribution of animal slurry, particularly by spraying and to some extent by run-off or seepage into watercourses or downward percolation into water-bearing strata, could cause some hazard to public health by the spread of bacterial, parasitic or viral diseases. Salmonellosis, common to animals and humans, is the most likely known cause of cross-infection.

342 Slurry can be more dangerous than farmyard manure in this respect because it is not always stored so long and is not normally subjected to the self-sterilising effects of composting. If, as sometimes happens, recently produced slurry is spread on to pasture being currently grazed, then other animals may become infected. Cases of poultry pathogens being passed in this way to dairy cows have now been recorded. Animals so infected provide an increased human health hazard, either by direct contact or through animal products such as meat, milk and eggs. Simple practical precautions can minimise risks. For example, slurry should be applied to arable land, not on grazing pasture or on growing crops—particularly if the crops are intended to be eaten uncooked. If slurry has to be put on pasture land this should not be grazed for at least six weeks. Slurry tanks should never be allowed to overflow. Unfortunately, the disposal of slurry on the land is often troublesome owing to the practical problems which so frequently beset farmers such as high rainfall, wet and heavy land, mudbound roads, frozen pipes and breakdowns in machinery.

Chemical Residues

343 Certain chemicals are now widely used as growth stimulants for animals. In particular, the use of copper in pig rations is fully justified by the scientific experiments which have been carried out and, indeed, was generally welcomed because to a great extent it has replaced the use of antibiotics in pig food. Unfortunately, a large proportion of the copper is excreted in the dung and it now appears that this can give rise to problems when a lot of pig slurry is spread on a small area of land. Copper accumulates in the soil, so there is a build-up over a period, and it persists for a very long time. These high copper levels can have a deleterious effect on plant growth but there is no evidence to show that plants grown on such land adversely affect livestock feeding on them. So far the problem can only be overcome by ensuring that manure from copper-fed pigs is not applied excessively to small areas of land.

344 Less is known about residues from other substances which are now included in animal diets. Owing to the diverse nature of the additives which may pass from the animals' manure to the soil, there is need for further

investigation into their persistence, if any, on or in the soil. Their effects are unlikely to be cumulative as with copper but could, nevertheless, be very serious if for any reason large quantities were suddenly applied to growing crops or got into plants eaten by grazing animals.

Nuisance

345 Smells normally arise on livestock units from the storage and spreading of manures and, to a lesser extent, from the animal housing. Smells from animal houses can be avoided—they are often a reflection of poor husbandry. The smells which arise from storage and/or spreading are much more troublesome and to date have not been satisfactorily avoided.

346 It is generally thought that smells arise from the anaerobic breakdown of the organic part of manure during storage. Smells are not apparent, however, until the store is disturbed, or the waste spread on land. Several methods of inhibiting this anaerobic activity and thus vastly reducing the smell have been found, but to date these have proved uneconomic or have had unwelcome side effects upon the soil or soil bacteria. Good husbandry advice can often help, but more research is needed.

Disposal to sewers and treatment

347 Some farms dispose of their slurry into the sewerage system, but this method would be quite impracticable and uneconomic for adoption on a national scale. The Armer Committee[5] recommendation, which led to the inclusion of farm effluents in the trade effluent legislation, was based on a view that not many farm effluents would be discharged to public sewerage systems. We understand that the evidence available at that time pointed to only a few hundred farms connected to public sewerage systems. The National Farmers' Union, in evidence, have told us that they are now aware of some 4,000 farms so connected and it would appear to them that the indications are that there could be as many as 10,000.

348 Animal wastes are similar to, though stronger than, domestic sewage and benefit from similar forms of treatment. Because they are stronger, a capital investment per head of stock, much larger than that per head of human population, would be required at sewage treatment works in order to deal with farm wastes discharged through the public sewerage system. We do not think that farmers should be encouraged to press sewerage authorities to make large-scale provision for animal wastes in sewerage and sewage disposal systems.

349 Some farm wastes are treated in oxidation ditches in which an attempt is made to reduce the BOD and suspended solids to acceptable levels for discharging to watercourses. The clarified liquids often contain large quantities of inorganic nitrogen and other plant nutrients from the decomposed manure. The United Kingdom dairy cow population has a yearly output of 180,000 tons of nitrogen, 120,000 tons phosphate and 370,000 tons potash.

350 A recent innovation has been the drying of poultry manure from large units. This product can be utilised as a fertiliser and it has been demonstrated that the dried manure can be both digestible and nutritive for cattle and sheep—a fact long since discovered by the farmyard forager! The dried product is mixed with cereals and other protein sources to form an acceptable diet at an economic price and this process may help considerably to dispose of this difficult by-product of the poultry industry. The immediate and obvious concern about pathogens being fed back to other animals does not as yet appear to have been justified. Fortunately, the drying processes which are essential to produce a marketable product also kill salmonella and the prevalent parasites. It is less clear, however, what effect chemical residues might have. So far the method has been largely confined to the product of laying birds which have not received medication. If it were applied indiscriminately to manure and litter from broiler units where poultry are given supplemented diets and disease medication, it might be detrimental to animals.

351 We agree with the Country Landowners' Association that the increasing emphasis in recent years on 'getting rid of' animal waste rather than 'using it' is mistaken and that farm wastes should be returned to the land wherever this is at all practicable. Every effort should be made to integrate this process into the changing techniques of good husbandry, so as to make the maximum use of natural and available raw material.

Other farm wastes

352 Crop wastes such as grass silage and pea-haulm liquors have a high pollution rating. The Ministry of Agriculture has issued a free short-term leaflet No. 87 on grass silage. Waste problems with pea-haulm liquors have fallen rapidly with the use of the mobile viner and advice is available on these problems from the National Agricultural Advisory Service.

353 The washing and pre-packing of vegetables may present increasing problems in waste disposal. Difficulties arise due to the large amount of water used and the subsequent disposal of the effluent, particularly when such processing units are located in rural areas and the local sewage treatment works cannot handle the volume. The satisfactory disposal of these wastes demands technical knowledge, and arrangements for research are being made.

354 Carcases, hides, feathers, bones, blood, etc are produced in undertakings varying from small "knackers yards" to large well-organised poultry processing plants. Most of these products are collected and processed for use, for example as fertiliser. The only products which may directly enter the sewerage system are plant washings containing some blood and other debris. There is no published evidence to suggest that this has given rise to serious animal health or public health problems.

355 Pesticides and insecticides (including plant sprays, sheep dip, container washings) present problems, although the farmer receives much advice and instruction. In particular the problem of sheep dip disposal is being actively investigated, but a fully satisfactory solution has not yet been reached.

356 It is clear that the problems of farm waste disposal are considerable. We are pleased to note that the Ministry of Agriculture, Fisheries and Food have a steering committee which not only keeps a constant watch on all developments in this field but also co-ordinates research, and initiates new developments both in its own organisation and outside. The committee has formulated a programme of work on which information and research is required. Some studies are already in hand.

Farm effluent problems and planning

357 Trends in marketing have often located intensive units near centres of consumption, while urban development has tended to spread around the farm, giving rise to

problems in disposal which did not exist before. The ubiquitous motor car has taken many urban dwellers to the countryside, either as commuter residents or in search of recreation, and they do not expect to find industrial conditions in these surroundings. The introduction of new legislation concerning river pollution and water resources has also raised planning problems new to agriculture. Local sewage disposal authorities cannot always cope with large volumes of effluent from new intensive units. We have looked at the existing system of development control over agricultural buildings, with these problems in mind.

358 Under planning law farm buildings are "permitted development", and therefore planning consent is not required except in the following circumstances:—

i. Buildings covering more than 5,000 sq ft (465 m^2). Any addition to such a building of less than 5,000 sq ft is itself subject to planning permission if it is erected within two years of the original building. After this two-year period has elapsed the building may be added to without planning consent, provided of course that each individual addition does not exceed 5,000 sq ft.

ii. Buildings of more than 10 ft (3m) high within 2 miles of an aerodrome; and more than 40 ft (12m) high elsewhere.

iii. Buildings within 80 ft (24m) of a trunk or classified road.

359 In addition to planning consent required for these types of farm buildings, consent under the Building Regulations is required for all new buildings and alterations to buildings. These regulations are mainly concerned with safety and drainage. Applications for consent under the regulations seems not always to be made; and it does not seem that they could be used as a suitable method for the control of farm effluent disposal.

360 The present planning procedure is as follows:—

a. Buildings Subject to Planning Control

In some planning authority areas an application is referred to the river authority to check whether the effluent disposal provisions are likely to work satisfactorily. We consider that this reference to the river authority should be made compulsory in all cases where any new or increased discharge to a watercourse is proposed.

b. Buildings NOT Subject to Planning Control

The only form of control exercised in these cases is that by the Ministry of Agriculture, Fisheries and Food when considering an application for grant-aid on these buildings. This application will be made in all except a minute number of cases. If they are doubtful whether the provisions for effluent disposal will satisfy the river authority, the Ministry officials will probably refer the matter to it.

We consider that the Ministry of Agriculture, Fisheries and Food should be placed under a duty to refer the matter to the river authority in cases where they are uncertain whether the new or increased discharge would be acceptable; and in all cases to remind the applicant that he is obliged to obtain the consent of the river authority for any new or increased discharge.

361 We considered whether to recommend the extension of planning control to more categories of farm buildings than those referred to in paragraph 358 above. Discussions are at present taking place between the Ministry of Housing and Local Government, the Ministry of Agriculture, Fisheries and Food and the Unions on this question. It is probable that planning control will be extended in the fairly near future to cover all farm buildings in the vicinity of residential areas.

FINANCIAL CONSIDERATIONS

Costs of treatment

362 The cost of processing trade effluent to the standards required by the river authorities falls on the firms concerned. We agree with the principle that the cost of processing industrial effluent should be regarded as part of the normal cost of production, which will be reflected in the price charged for the goods produced.

363 Firms may themselves pay the running costs of processing trade effluent; they may pay local sewage authorities to process it; or they may process their trade effluent to some extent and pay for the remainder of the treatment at the local sewage works.

364 Similarly, firms may themselves pay for the capital costs of trade effluent treatment plant or pay local authorities for installing treatment plant capable of processing the trade effluent.

365 We are glad to note a recurring theme in evidence to the effect that industry appreciates its role in the abatement of water pollution, is willing to pay its fair share of the cost of the treatment and disposal of wastes, and generally can be expected to adopt a responsible attitude to the needs of the community. On the amenity side, it has been suggested in evidence submitted, that it would be of considerable assistance in the fight against water pollution, if industry in general were to be offered incentives to discharge only innocuous effluents through greater taxation reliefs or more generous allowances for the installation of special anti-pollution plant.

366 Investment grants are payable by the Ministry of Technology (previously by the Board of Trade) under Section 1 of the Industrial Development Act 1966, towards expenditure incurred by a person carrying on a business in Great Britain in providing new machinery or plant for use in a qualifying industrial process or in related scientific research. The qualifying industrial processes cover the whole range of manufacturing industry, mining and quarrying, and the construction industry. They exclude the service industries, laundries, and distribution. Machinery and plant provided for the purpose of processing trade effluent generated in the course of a qualifying process are among the assets which are eligible for grant. The current rates of grant are 40 per cent in the development areas and 20 per cent elsewhere. It is the basis of the Act that only a person who both incurs expenditure on eligible assets and uses them in the course of his business can receive grant on them. Grants are not payable on capital contributions which a manufacturer may make to a local authority towards the cost of the authority's own effluent plant. The Industrial Development Act expressly prohibits the payment of investment grants to local authorities for any purpose.

367 The Confederation of British Industry (CBI), not unnaturally, represented to us that the operation of the Industrial Development Act, as it applied to effluent treatment costs, produced anomalies. An industrialist who installed his own treatment plant received an investment grant, but the rate (40 per cent in development area, 20 per cent outside) was determined by the accident of location, not by criteria relating to the effluent. A more serious

anomaly was that an industrialist who discharged to the sewer and made a capital contribution to the local authority to meet the extra cost of plant to treat his discharge did not receive any grant. This causes a financial deterrent to the general policy (with which the CBI agreed) that industrial effluents should, wherever possible, be discharged to the public sewer. The CBI suggested that effluent treatment financing should be removed from the Industrial Development Act and incorporated in new legislation and that this should make provision for capital grants. The National Farmers' Union and the Country Landowners' Association in general supported the views of the CBI.

368 We accept the representations as valid criticism of the present grant arrangements, which may lead to conflict with the best remedial measures for the avoidance of water pollution. We consider that there should be new legislation to make grants available to industrialists and farmers towards their capital contributions for treatment works provided by local authorities. We make no recommendation about the actual proportion of grant-aid, but consider that grants or allowances for the treatment of liquid trade wastes should be no lower than for other plant and machinery.

369 The present system of grants available to agriculture for capital expenditure on effluent treatment is more complicated than that available to industrialists under the Industrial Development Act 1966. In agriculture, effluent treatment plant is likely to attract only the 10 per cent investment grant on fixed equipment not otherwise qualifying for special improvement grants. In theory the farm improvement grant is available but the National Farmers' Union have told us in evidence that grant conditions are such that in most cases assistance for sewage disposal is not permissible, especially where the fixed equipment is associated with an intensive unit.

370 We are aware that the grant structure is intended to be simplified by the provisions of the Agriculture Bill which was before Parliament at the time of reporting. Nevertheless, this does not detract from our general view that agriculture should receive no less benefit in general than other forms of industry. We consider that medical and veterinary research farms should qualify for any general grants for effluent treatment. Grants to manufacturers should be available for experimental plant installed on farms to help develop new methods of farm effluent treatment.

Effluent charges

371 Local authorities in England and Wales have a general obligation to accept trade effluents into their sewers, provided that the discharges will not adversely affect the sewers or prejudice the sewage treatment processes. They may attach conditions of consent to acceptance of a discharge, and in particular require the payment of charges reflecting the cost of the reception, treatment and disposal of the industrial effluent.

372 Many organisations have drawn attention to the wide variations in methods of calculating industrial effluent charges, which mean that the cost of discharging similar effluents to sewers varies without economic cause between one local authority area and another. The Rural District Councils Association have said that some councils make no charges in order to encourage industries to settle in their area. Attention has also been drawn to the regrettable lack of uniformity in the costing of, at least, some aspects of industrial effluent treatment costs and to the many different bases used for charging. The Sewage Purification and Disposal Statistics published by the Institute of Municipal Treasurers and Accountants[6] demonstrate that the trade effluent charges made by many local authorities do not cover the costs of treatment.

373 We value this self-criticism from the local authority sector and accept that many of the present methods of assessing trade effluent charges omit a proper proportion of central establishment charges, notional loan charges and credits. We consider that there should be some standardised basis of charging applicable throughout the country. We are aware that many authorities adopt a method based on the 'Mogden formula'[7] or one of its variants. This method reflects costs for conveyance, reception and treatment, and although we are not making a recommendation for adopting any particular formula, we do consider that any national formula that may be devised should be based on such considerations.

374 Even if a standard national formula for the calculation of industrial effluent charges is devised, we emphasise that this will not lead to a standard charge either generally or for effluents of a similar nature. We are advised that charges vary from as little as 2d to as much as £1 or more per 1,000 gal (4,500 l) according to the character of the waste and local conditions. Some industrial evidence has pointed out that variations in charges for the same type of waste in different areas can have a serious effect on the economics of specific industries. Suggestions have been made for a balancing fund on a national basis; for scales of standard charges applicable nationally for comparable industries; and for a treatability factor allowance.

375 Variations in charges between firms and areas are inevitable and we reject the suggestions that there should be national standardised charges or some form of equalisation. Charges for similar volumes of industrial effluents from different firms in the same area are bound to vary according to the nature and strength of the effluent. Equal charges would act as a deterrent to efforts to produce less polluting trade effluents. One firm should not be required to subsidise another (which would be the effect of equalisation). Costs, and hence charges, in different areas vary according to the proportions of industrial effluent and domestic sewage load, the size, age and operational efficiency of the sewers and sewage works. The worst anomalies will, in our view, be removed if sewage treatment is transferred to some larger authority and costs can be spread over bigger and more evenly balanced areas than at present.

Recommendations

376 All discharges of industrial effluent to public sewers should become subject to control and liability for charges; such charges should be applied throughout the country by a common formula reflecting conveyance, reception and treatment costs. (Paragraphs 325 and 373).

377 Crown properties such as hospitals, prisons and like establishments should be brought within the scope of the trade effluent provisions, and they should consult with sewage authorities in the event of new building or conversion of old buildings. (Paragraph 327).

378 The Pipelines Act 1962 should be amended to facilitate the installation of pressure pipelines for waste waters or sludges. (Paragraph 330).

379 Animal wastes should be returned to the land wherever possible. (Paragraph 351).

380 Legislation should be introduced to make grants available towards the capital contributions paid by industrialists and farmers to local authorities for trade effluent

treatment plant facilities at the same rate as the grants or allowances made to industrialists and farmers who install their own treatment facilities. (Paragraph 368). Overall, agriculture should receive no less benefit than other forms of industry. (Paragraph 370).

381 River authorities (or their successors) should be included as "interested parties" under the drainage of trade premises legislation (Paragraph 322).

381 Legislation should be introduced to require further precautions to avoid accidental pollution of water from the use or storage of oil or toxic substances. The law should also be changed so that persons and organisations permitting pollution by oil or toxic substances of watercourses, directly or indirectly, could be successfully prosecuted and made liable to a fine commensurate with the seriousness of the offence. (Paragraphs 155 and 333).

References

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Chapter 8 Education, Training and Research in Water Pollution Control

Education and training

383 The water pollution control services should be regarded as a vital and major industry: vital because they protect our most valuable natural resource, and major because of the considerable capital investment in these services of currently around £100 million per year for sewerage and sewage treatment, together with a total capital value of existing facilities at present-day prices of at least £1600 million. It is one of the most capital-intensive industries in the country in relation to the numbers of persons employed. It has been estimated, for one of the larger works completed during the last decade, that the capital per person employed (staff and workmen) was about £55,000, and considering the management staff alone the figure was about £245,000[1]. If the best use is to be made of such investment, then adequate and proper facilities must be available for the education and training of the staff.

384 We have seen that some of the reasons for the poor quality of sewage effluents are works which have been inefficiently designed or which are not properly operated or maintained. In many cases these deficiencies are due to a lack of suitably qualified and properly trained personnel for this specialised work. We have mentioned in Chapter 2 that the composition of sewage is complex and that its character and strength may vary according to the activities of industry and people. It is evident that for the satisfactory treatment of these wastes a proper understanding of the processes involved is needed. We have made recommendations which will require higher and more consistent standards of sewage treatment, and realise that these recommendations cannot be fulfilled without the necessary technical staff.

385 We have been impressed by the enthusiasm and competence of those engaged in water pollution control despite all the evident disadvantages of their work and, in many cases, the lack of formal training they have received because of shortage of suitable facilities. Although many local authorities are rightly proud of their achievements in sewage treatment, some do not regard this service as important. We know of well-managed works which have never or rarely been visited by the Councillors responsible for them. Some councils are indifferent to the need for trained staff; indeed, there are instances where it has been made clear that qualifications were not desirable as qualified staff required higher salaries! Recent advertisements in the press for sewage works managers of medium-sized works offer salaries generally within the range of £1500–£2000 per annum, though of course managers of large works will normally receive considerably higher salaries than the upper figure indicated. We do not consider the average emoluments to be compatible with the importance of the job or with the responsibilities involved. In some cases it would be appropriate for such officers to be considered as 'principal officers' and paid accordingly, whilst in the large authority the necessary professional qualifications and responsibilities might warrant 'chief officer' status.

386 The consequence of the many small sewage disposal authorities, the lack in some instances of enforcement of high standards of treatment and the lack of public interest in the service, is that the sewage treatment profession lacks a proper status and career structure. We find that many employees enter the profession by chance rather than by design and consequently the number who have had formal training for their important job is quite small, although a large number manage to train themselves for the excellent purpose-designed examinations of the Institute of Water Pollution Control.

387 A smaller number of large authorities will allow the development of better conditions of service in water pollution control. Meanwhile plans should be made to remedy the deficiencies in education and training. There are three principal levels of training to be considered:

- (a) Undergraduate and postgraduate courses at universities for the designers of sewage and sewage treatment works, senior management staff of large sewage authorities and chief pollution prevention officers of river authorities.
- (b) Professional training leading to membership of appropriate Institutions for managers of sewage works and district inspectors of river authorities.
- (c) Technician training for operators and attendants of sewage treatment works.

In addition, the Water Pollution Research Laboratory (see paragraph 397), with their knowledge, facilities and expertise, are in a special position to provide training courses of

differing content to meet the requirements of all personnel engaged in the many aspects of water pollution control.

University training

388 The design of sewage treatment works is traditionally the responsibility of civil engineers whose training is centred on mathematics and the physical sciences and their applications to structural design, soil mechanics, hydraulics and surveying. With advancing technology, it is necessary for the designers of sewage treatment works also to have sufficient knowledge of the basic sciences such as microbiology, chemistry, biochemistry, and freshwater biology, and their applications to unit processes and treatment systems, to know when to seek expert advice. One-year courses in public health engineering can be designed to provide the necessary specialist training.

389 We are advised that postgraduate instruction makes a greater impact on a graduate after he has had a few years practical experience in the appropriate field. A return to university at this stage is not easy as he may have acquired professional and family responsibilities, and such grants as are available may not be adequate. At the present time the few postgraduate courses available make a totally inadequate contribution to this country's needs—a total of less than 20 persons per year take these courses. It is vital to ensure that a greater number of British engineers undertake postgraduate study of this kind by encouraging employers to second members of their staff for such courses. The main need is for more, and more generous, study grants and we hope that the assistance of the Research Councils and Training Boards will be forthcoming. It is not thought that, for the present, any increase in the number of courses is necessary, though if the increased support we consider necessary materialises, then additional courses could well be required.

390 The controlling officers of large works and the senior management staff of sewage disposal authorities usually have a university degree or equivalent qualification in either chemistry or civil engineering. The existing postgraduate courses in public health engineering cover their needs, and also those of chemical engineers and plant manufacturers engaged in the design of treatment plants for industrial effluents.

391 River pollution prevention officers have responsibility for river water quality which, as we have stated elsewhere, is an important factor in the proper management of our water resources. Most chief pollution officers and their deputies are university graduates in chemistry and have had practical experience in sewage treatment. It is increasingly desirable that science graduates entering the service of river authorities should take advantage of the postgraduate courses available.

Professional training

392 It is in the field of professional training that there is the greatest need for improvement. The majority of managers of sewage treatment works are corporate members of the Institute of Water Pollution Control and, in turn, a majority of these have qualified by passing the Diploma examinations of the Institute. It is difficult to over-emphasize the importance of the Institute's Diploma examinations in this field. They provide an objective measure of professional competence, and offer a stimulus to the young entrant to the profession to train himself and thus improve his knowledge and status. Unfortunately at the present time systematic instruction for the examination is only available in the home counties, Birmingham and Manchester, and the young man must usually depend on his own enthusiasm and on the help given by his older and experienced colleagues. We consider this is no longer good enough and that adequate study courses should be provided.

393 Last year some 150 entrants sat the first part of the Institute's Diploma examination; this number, spread over Britain, is insufficient to support evening or day-release classes in all the necessary centres. Yet it is essential that formal instruction for the Institute's examination should be given wherever possible. We suggest that this can be achieved only by concentrating the instruction in a comparatively small number of centres, say 6–10, and recruiting for these courses by block release. The present difficulties of small authorities in releasing staff for training courses would be largely overcome by the formation of larger sewage disposal authorities as mentioned elsewhere in the report. It is hoped that the Department of Education and Science, in collaboration with the Training Boards, will take early steps to initiate courses on the lines suggested. The implementation of this proposal would meet the training needs not only of sewage works management but also of district inspectors of river authorities, trade effluent inspectors and those responsible for trade effluent treatment plants. The Institute of Water Pollution Control would continue to act as the examining body. We consider that each manager responsible for one or more works serving a combined population equivalent to more than 15,000 persons should be required to hold the Institute's Diploma or a University degree (or equivalent) in science or engineering. For the large works at the other end of the scale, we have seen in paragraph 390 that the controlling officers normally have a university degree or equivalent qualification. We consider this to be an essential requirement, and in fact are of the opinion that for a works serving 500,000 persons or more the manager should be required to have an honours degree (or equivalent) in science or engineering *and* be a corporate member of the Institute of Water Pollution Control.

Technician training

394 The day-to-day operation of a sewage treatment works requires skilled and trained operators. This is of particular importance in the small works which do not warrant the full-time attention of a professionally qualified staff. The only training facilities for these workers at the present time rely on the voluntary activities of such bodies as the Institute of Water Pollution Control, the Association of Rural District Council Surveyors and some river authorities. Although these courses are extremely valuable the number of them is totally inadequate to meet requirements. It is wrong for such an important matter to be left to the initiative of a few enthusiastic volunteers, and we feel there is a need for several courses to be organised at district centres leading to a technician's certificate. No such certificate exists and the matter should be given urgent consideration by the Training Boards. The technician courses should be designed to enable the more able and ambitious technicians to proceed in due course to improve their status by studying for the Institute of Water Pollution Control Diploma. It seems likely that the most suitable arrangement for technicians' courses will be block release.

395 In conclusion we consider that our suggestions for education and training outlined in the preceding paragraphs would provide for a proper career structure with opportunities for advancement for all grades engaged in the field of sewage treatment and water pollution control. In turn this

should allow the further development of pride and satisfaction in the work, stability in employment, and due regard for the devoted service so often given.

Research

396 The total expenditure in this country on research into sewerage, sewage treatment and the effects of pollution is probably no more than one per cent of the total gross expenditure in this field. The evidence submitted to us and our own enquiries show that this research has given great benefit in the past in advancing the technology and understanding of waste treatment and water pollution control. Research should continue on an expanding scale in the future to keep pace with changing circumstances.

397 The main centre for research on methods of sewage treatment and disposal and on the effect of polluting discharges on natural waters, is the Ministry of Technology's Water Pollution Research Laboratory at Stevenage, to which reference has already been made a number of times. The research is aimed at improving both the technology and the economics of processes and at providing information needed to control pollution. The Laboratory has about 100 technical staff qualified in the varying disciplines needed for this work, and currently (1970) operates on an annual budget of no more than £400,000. Responsibility for deciding the Laboratory's programme of research rests with a Steering Committee, which includes senior members from the Confederation of British Industry, the Ministry of Housing and Local Government, the Natural Environment Research Council and the Water Resources Board. The Steering Committee takes advice from several organisations, for example, the Institute of Water Pollution Control, the Association of River Authorities and the Confederation of British Industry. Results are disseminated in various ways, including answering enquiries both on an ad hoc basis and through the special information Service on Toxicity and Biodegradability of Individual Substances (INSTAB) referred to in Chapter 7; publications; lectures; open days; exhibitions and attendance at the many committees on which the Laboratory is represented.

398 Thus the Laboratory draws on a wide experience of varying interests in devising its programme of work, and also makes a positive effort to publicise its findings. We are in no doubt as to the value of the work carried out; it is highly regarded in this country and elsewhere in the world.

399 The Water Pollution Research Laboratory is however controlled by the Ministry of Technology and we have reservations about the wisdom of this. The Laboratory deals primarily with a natural resource—the quality of sewage and industrial effluents and river water—and its only link with the Ministry of Technology is presumably through the service it provides to industry. It could be argued that it would make more sense to transfer the Water Pollution Research Laboratory to the Natural Environment Research Council, which is concerned with natural resources. Alternatively it has been suggested that the Laboratory should be placed in the Ministry of Housing and Local Government, which is better aware than any other Government department of the problems in sewage treatment confronting local authorities. In our view, however, the work of the Water Pollution Research Laboratory, and of certain other centrally-funded research organisations concerned with water such as the Water Research Association, could be better controlled by a new central water authority, which we recommend should be set up (see Chapter 9).

400 A considerable amount of research in water pollution control is also being carried out by some of the larger local authorities, by certain universities, by industry and by other organisations such as the Natural Environment Research Council and the Ministry of Agriculture, Fisheries and Food. We find that, while there is no single body with ultimate responsibility for co-ordinating and reviewing the activities of the various agencies dealing with the problem, a good deal of informal collaboration does exist by virtue of common representation on the several committees and working parties which have been brought into being to examine special problems. Also, we are pleased that a liaison committee has been recently set up to co-ordinate research in the universities with that carried out at the Water Pollution Research Laboratory. We envisage that the proposed new central water authority would exercise, in a general way, some co-ordination of research effort.

401 We have already made some recommendations elsewhere in the report for research into particular aspects of sewage treatment and pollution control. These include: full-scale trials of promising laboratory developments; more flexible design of sewage treatment works; effect of sludge and waste disposal on estuarial and marine ecology; the effects on crops and soil structure of irrigating with polluted river water; and the development of alternative nitrogen fertilisers.

402 There are of course many other problems requiring research, as has been amply indicated in the evidence submitted to us. The main problem at sewage works is the treatment and disposal of sludge and priority should be given to the further development of the use of chemicals and mechanical methods for sludge drying, and to the incineration of sludge. Of equal need for urgent investigation is the development of economic methods for the treatment and disposal of farm wastes and for the removal of nutrient salts and organic residues from polluted waters used as sources of potable supply.

403 Increasing difficulties are likely to be experienced in finding sites for the final disposal of sludge and concentrated industrial wastes especially those with toxic properties. In order to plan the best use of available sites more precise knowledge will be required about the extent to which polluting materials are leached out by rain and about the consequences of percolation of contaminated water through the ground. Additional research is also needed on the virological aspects of the use of reclaimed water for potable supply and on the long-term effects on health of trace organic residues in such water; on the feasibility of minimising the volume of domestic sewage, possibly by the use of the vacuum system referred to in Chapter 2; on the feasibility of simplifying plant design along the lines of the oxidation ditch version of the activated sludge process; on the use of automation and computer techniques in pollution control; on the re-use and recycling of water; on the feasibility of optimising the design of sewerage systems to cater for storm flows in the most effective way, possibly by using a storage system to collect the first flush of highly polluted overflow; and on the development and application of alternative criteria for assessing pollution which are more specific and more readily determined than BOD.

404 Research into some of these problems is already being carried out, but it is obvious that considerably greater facilities are required in this country if even a few of the many problems are to be properly investigated. It has been suggested to us that as an immediate expedient the present allocation of funds to the Water Pollution Research Laboratory should be doubled; with this we concur, appreciating that this will necessitate a substantial increase in the

Laboratory's staff complement, and the recruitment of the appropriate technical personnel. We envisage that some of this work would be operational research which need not necessarily be carried out at the Laboratory's premises. We also recommend that more research by other organisations should be supported wherever it can most appropriately be carried out.

405 It is of course necessary for the knowledge gained through research to be utilised in full-scale practice. In Chapter 2 (paragraph 80) we have referred to the difficulties which face local authorities, consulting engineers and equipment manufacturers when they wish to incorporate novel ideas into schemes, and we have made recommendations which we hope will resolve these difficulties to some extent. This is however only one side of the problem. During our investigations it has become apparent to us that some local authorities, in particular the smaller ones, have no knowledge of the results of research work which has been carried out and consequently of the benefits in sewage treatment design and operation which have ensued. This is unsatisfactory and it is clear that such authorities should be made aware of recent developments and if possible put them into effect. We suggest that the Directorate of Engineering in the Ministry of Housing and Local Government and the Welsh Office which is in touch with the local authority officers responsible for sewage treatment, might well play a useful part in giving the necessary advice, though ultimately the proposed central water authority, referred to above, should undertake this work.

406 We conclude that research is necessary to improve the cost-effectiveness of treatment and disposal, to develop and assess new and alternative processes, to overcome problems resulting from the development of new chemicals appearing in sewage, and also to assist the British sewage plant industry to compete effectively overseas. We have made suggestions for work required and recommendations to increase the research effort. With the ever changing conditions in the field of pollution control we cannot over-estimate the value of such work and we would like to see early implementation of these recommendations.

Recommendations

Education and training

407 Greater support should be given to existing post-graduate courses in public health engineering and other relevant courses by qualified engineers and scientists working on the design and operation of sewage treatment works and in water pollution control. To achieve this, employers should be encouraged to release suitable personnel and the appropriate Training Board should be asked to help finance this training. (Paragraphs 388–391).

408 There should be an extension of training courses at professional level for the Diploma Examinations of the Institute of Water Pollution Control, and the organisation of training courses at technician level for operators of sewage treatment works leading to a technician's certificate. In each case the courses should be organised on a block release basis by the appropriate Training Board, who should provide adequate financial assistance. (Paragraphs 392–394).

409 The Water Pollution Research Laboratory, having much to offer in the training of personnel in each of the three categories of design, operation and control, should hold frequent courses. These courses should be concerned not only with new or recent developments, but also with earlier work now accepted as sound practice. (Paragraph 387).

410 Managers responsible for sewage treatment works serving a total population equivalent to more than, say, 15,000 should be required to hold the Diploma of the Institute of Water Pollution Control or a university degree (or equivalent) in science or engineering. Managers responsible for large works serving 500,000 persons or more should be required to have an honours degree (or equivalent) in science or engineering and be corporate members of the Institute of Water Pollution Control. (Paragraph 393).

Research

411 The present allocation of funds to the Water Pollution Research Laboratory should be at least doubled and increased allocations made to other governments research organisations concerned with water pollution. Universities and sewage disposal authorities should be encouraged to carry out more research in water pollution control. (Paragraph 404).

412 A more positive policy should be made to implement the knowledge gained from research. (Paragraph 405).

413 The laboratories of research organisations concerned with all aspects of water should be placed under the control of the proposed new central water authority. (Paragraph 399).

414 Priorities for research should include: treatment and disposal of sewage sludge; treatment and disposal of farm wastes; removal of nutrient salts and organic residues from polluted waters; and development of improved criteria for assessing pollution. (Paragraphs 402 and 403).

Reference

[1] Allen, F. W. Contribution to discussion of paper by J. R. Simpson, J. Inst. Sew. Purif., 1965, (2), 146.

Chapter 9 Future Administration

415 We have studied the problems of disposing of sewage without causing risks to public health or destruction of the natural assets and delights of our environment. We have made recommendations for legislation, policies and practices towards achieving these aims. We find the modern methods of sewage treatment used in this country to be not only as advanced as anywhere in the world, but also more extensively applied. None the less in many areas facilities are totally inadequate to meet present-day needs and considerably greater development and expenditure is required. Yet the problems of today are not nearly as formidable as those that will be presented in the future as the use of water and the amount of sewage increase. A much stronger administrative structure is required not only to control pollution, but to plan and integrate policies for the whole of the water cycle, including supply, use, purification, and, especially, re-use of water.

416 It has for some time been generally agreed that the areas of sewage disposal authorities should be much larger. The Royal Commission on Local Government in England suggested that 58 unitary authorities and 3 metropolitan authorities should take over sewage disposal functions in England, outside Greater London, replacing the existing 1,200 authorities. The Local Government Commission for Wales suggested that 35 new county districts and 4 joint boards should be the sewage disposal authorities, replacing the present 6 joint boards and 168 authorities. If there were fewer sewage disposal authorities than at present, many of the defects we have noted in the present system of administration could be removed. The incidence of the cost of sewage treatment would be more evenly spread; it would be financially possible to employ qualified staff to manage all sewage treatment works; and staff would have a more attractive career structure.

417 But there are defects other than size of areas in the present system of administration. When sewage disposal functions are not based on river basin catchment areas, each authority for sewage disposal cannot by its own efforts prevent water pollution by sewage effluent. The rivers in its area can be polluted by sewage effluent discharges upstream. Similarly sea winds, tides and currents can carry pollution from one coastal local authority area to another.

418 Thus, by its nature, sewage disposal does not have a firmly localised basis, as when benefits are directly produced for local residents in return for some expenditure by them. Although sewage treatment is now a service in which the general public is showing more interest and people are increasingly concerned about the local environment, the quality of water in a particular place is often determined by sewage disposal arrangements elsewhere.

419 In the future new techniques may be used in sewage disposal to avoid river pollution. For instance, the River Trent study will be examining retention lakes, re-aeration techniques, piping or tankering selected effluents for collective treatment, temporary storage, piping effluents to the lower reaches of the river, and disposal of toxic wastes to the sea by tanker or pipeline. Sewage treatment works may become only one of the possible methods of avoiding river pollution. The scale of sewage treatment is, however, likely to increase and to require staff who are qualified for and experienced in this particular work. There is also a need to link the planning of all new development more closely with the planning of adequate sewage treatment capacity, whatever authorities are responsible for each in the future.

420 The present river authorities have responsibility for the management of rivers and estuaries, but in practice are not able to compel the expenditure on sewage treatment necessary to produce effluent of the required standards. Nor are they able to require the siting of sewage works to get the greatest benefit from expenditure on treatment.

421 The river authorities are responsible for maintaining river flow, but although a significant part of the flow is often sewage effluent, river authorities cannot require sewage effluent to be discharged to a particular river. River flow can diminish unacceptably if, for instance, the sewage effluent discharged into it is diverted for re-use to an industrial undertaking discharging effluent into another river.

422 There is no rational system of allocating costs between the dischargers and the users of river water. Dischargers do not pay for the use of the purification capacity of the rivers, but abstractors pay for the use of water. The treatment costs of dischargers vary according to the standards required by users, and the treatment costs of users vary according to the amount of discharge and the standards attained by the dischargers. With the existing division of responsibility it is not easy to secure the optimum use of a river so as to obtain the biggest benefit at, relatively, the lowest overall cost.

423 The expenditure on sewage disposal is at present met from the rates, with the addition of general Exchequer grants according to the needs and resources of local authorities. Expenditure on the prevention of pollution is met by precepts on the rates. Financing expenditure from the rates may well prove too restrictive in the future; when the administrative structure is reorganised the opportunity should be taken to overhaul the financing of sewage disposal. It will be well worth considering whether charges should be levied on dischargers for their use of the limited natural assimilative capacity of a river, just as charges are now made for the abstraction of river water. Pending reorganisation of the administrative structure, special temporary Exchequer aid should be given to avoid any

unreasonable increase in local rates as a result of improvements in standards of sewage disposal.

424 When the Water Resources Act 1963 extended the responsibilities of the Minister of Housing and Local Government to the formulation of a national policy for water a technical organisation, the Water Resources Board, was set up to advise him. The present system of planning water conservation, relating principally to its quantity, could not work well without the expertise of the Water Resources Board. Although it does not have power to execute policy, it performs many technical functions. It is systematically surveying the needs for water and sources of supply in each region of the country; it has developed a computer-based system of hydrometric records; it is developing instruments to record quality and is studying the possibilities of desalination and estuarial barrages.

425 The Water Resources Board has only limited functions relating to water quality, but it is already apparent that in practice water quantity and water quality are so indissolubly linked that the Water Resources Board is inevitably involved in questions of water quality, for example, in the River Trent Study. This study is being carried out by a specially constituted committee, under the chairmanship of the Director of the Water Resources Board. It is examining a wide range of means of meeting the possible demands for water in the Trent River Authority area, including the treatment of the polluted river water in the Trent to make it suitable for public or industrial supply. We consider that the administrative structure should be such that studies of this kind could be carried out as part of a normal process of planning for water use and re-use, rather than by ad hoc arrangements. When decisions have to be made as a result of such studies, co-ordination of policies for water conservation, river management and sewage treatment are essential. Looking ahead, we are convinced that to formulate and apply the necessary strategy for water conservation and reclamation a new central authority is required with comprehensive powers for planning water quality and quantity, within the general control of the Minister of Housing and Local Government and the Secretary of State for Wales.

426 The main function of the new central water authority, as we envisage it, would be to plan our water resources, including used water, for anticipated needs, and to exercise reserve powers to enable its plans to be enforced. It would have overall planning powers over the successors to river authorities; and with them would decide which rivers were needed for public water supply, for cooling processes, and for industrial and agricultural use. The successors to river authorities would then be able to determine whether used water should be discharged into particular rivers, to estuaries or to the sea, or whether it should be used direct by industry, and how the necessary river water quality could best be monitored. The new authority would take account of recreation, amenity and fishing. The Water Pollution Research Laboratory should be attached to the new central water authority, as an autonomous unit, together with other research organisations concerned basically with water. As well as giving purpose to the direction of research work into the water cycle there should flow from this arrangement the advantage of greater interchange of staff between research, treatment and control, ensuring a wider experience, greater knowledge and a greater sense of direction.

427 The new central water authority would have to employ staff qualified in the various sciences concerned with the condition of water. Such a scientist should be appointed Director of Water Quality within the new authority. We realise that these suggestions may be regarded as outside our terms of reference, but our studies have convinced us of the impossibility of considering sewage disposal methods other than in the context of the management of total water resources.

428 At present the Minister of Housing and Local Government has the conflicting duties of promoting policies to develop national water resources and adjudicating on the proposals when translated into action. The Minister has to oversee the working of the present administrative structure and at the same time work within it. He is answerable to Parliament for the overall policy and also for its detailed implementation. It would be more sensible to set up a technically based national authority outside detailed departmental control, while leaving to the Minister his overall responsibility for general policy, for the level of investment and for his semi-judicial functions.

429 At the local level, responsibility for local sewers, apart from main sewers, should remain with the local authorities. This division of responsibility between local sewers, and main sewers and sewage disposal works has been in operation (for many years in some cases) where joint sewerage boards are in existence, and in the Greater London Council sewerage area. We know of no particular difficulties caused by these arrangements; on the contrary, joint sewerage boards have been represented to us as providing an efficient and effective form of organisation. Where trade effluents are discharged to local sewers we consider that control over trade wastes should be the responsibility of the authority for sewage treatment.

430 Our conclusion on local management of sewage disposal is that, whatever authorities are responsible for administration, there should be integration of sewage and water functions, locally as well as nationally and regionally. Sewage consists of 99·9 per cent water and its disposal comes logically within the water cycle. In order to integrate sewage disposal with water conservation and management the administration of these functions should be based on catchment areas. Sewerage is primarily a gravitational system and systems are confined to catchment areas of rivers. We envisage that such catchment boards or councils (which might well be named after the main river in their area) should be responsible for controlling sewage disposal from the relevant coastline and to the sea up to the three-mile limit.

431 We have not tried to spell out a new administrative or financial structure in detail as our terms of reference covered sewage disposal only and the Central Advisory Water Committee is advising on the future public administration of both sewage and water functions. But our investigations have clearly demonstrated the need for sewage disposal to be considered as part of the whole water cycle, together with water conservation and the control of the quality and quantity of flow in our waterways.

Chapter 10 Summary of Main Recommendations

Policy and finance

432 A more positive policy is required for freshwater quality, integrated with the forward planning for water quantity, both nationally and locally. (Paragraph 156).

433 Public investment in sewerage and sewage treatment plant must be increased substantially to enable adequate facilities to be provided at works for the production of satisfactory effluent. (Paragraphs 50–51 and 159).

434 There should be a deliberate policy to improve rural sanitation with priority for the replacement of earth and pail closets and the elimination of sewer ditches. (Paragraphs 281–292).

435 The Government should support the formulation of international agreements to control sea pollution. (Paragraph 267).

Administration

436 The authorities responsible for water resources should strictly control the quality of discharges according to their agreed programme of improvement. (Paragraph 158).

437 The authorities responsible for water resources should closely consult Sea Fisheries Committees or the Ministry of Agriculture, Fisheries and Food, on estuarine and coastal discharges. (Paragraphs 209 and 270).

438 The expansion of existing industries or the siting of new industrial premises for the manufacture of fine chemicals, pharmaceutical or agricultural chemicals, should be carefully controlled where these industries have to discharge trade effluents directly or indirectly into rivers used as sources of public water supply. (Paragraph 128).

439 Crown properties such as hospitals, prisons and like establishments should be brought with the scope of the trade effluent provisions. (Paragraph 327).

Statutory law

Extended control of discharges

440 The powers of the authorities responsible for managing water conservation should be extended to control all discharges to tidal rivers and estuaries, to the sea by drains or pipe-lines, and to dumping at sea within the three-mile limit. (Paragraphs 202, 264–272).

441 The powers of these authorities over discharges to underground strata should be extended. (Paragraphs 299–307).

442 The statutory duty of the authorities responsible for water conservation to carry out a survey of the water resources of their areas should include surveys of the quality of water in all rivers, canals and estuaries, related to their present and intended future uses. (Paragraphs 167 and 211).

443 Discharge of sewage from boats into freshwater used for recreation should be prohibited (Paragraphs 117–121). Discharges from ships, including naval vessels, into estuaries and tidal rivers should be controlled where necessary by the authorities responsible for water conservation. (Paragraph 207).

444 Applications to discharge to inland watercourses should be advertised in the same way as water abstraction applications. (Paragraph 164).

445 The central government should be given statutory powers to control the dumping of waste beyond the three-mile limit. The control of dumping should apply to British ships or ships using British ports. (Paragraph 267).

446 The law should be amended, both to require better safety procautions against accidental pollution of water by oil or toxic substances, and to allow persons permitting such pollution to be effectively prosecuted. (Paragraph 333).

Adequate sewage treatment

447 Planning authorities must be required by law to consult the authorities responsible for river management and for sewage disposal on plans for new development, which should not be allowed without adequate capacity for sewage treatment. (Paragraphs 162 and 163).

448 The right of connection of domestic properties to a public sewer should be withdrawn and replaced by a sewer connection notice procedure. (Paragraph 162).

449 Discharges of unscreened storm sewage should be prohibited. (Paragraph 30).

Industrial effluents

450 All discharges of trade effluent to public sewers should become subject to control and liability for charges, which should be based on a common formula and applied throughout the country. (Paragraphs 325 and 373).

451 River authorities or their successors should be included as interested parties under the drainage of trade premises legislation. (Paragraph 322).

452 Legislation should be introduced to make grants available towards the capital contributions paid by industrialists and farmers to local authorities for trade effluent treatment plant facilities payable at the same rate as the grants or allowances made to industrialists and farmers who install their own sewage treatment facilities. (Paragraph 368).

453 The Pipelines Act 1962 should be amended to facilitate the installation of pressure pipelines for waste waters or sludges. (Paragraph 330).

Sewage disposal and sewerage in rural areas

454 When a local authority provides a new main sewerage scheme all properties with cesspools or septic tanks near the line of the sewer should be connected to the sewer at the local authorities' expense. (Paragraph 292).

455 Local authorities should provide a free and sufficiently frequent cesspool and septic tank clearance service. (Paragraph 285).

Sewage disposal methods

456 Sewerage in new development should separate foul sewage from surface waters. (Paragraph 30).

457 Government funds should be made available to (1) finance full-scale trials at sewage works of proven laboratory-scale projects, and (2) underwrite the costs of full-scale plants at sewage works involving newly-developed processes. (Paragraph 80).

458 Changes in conventional methods of construction of sewage treatment works should be investigated with a view to the production of shorter life plants. (Paragraph 78).

459 Wherever possible encouragement should be given to the application to agricultural land of suitable sewage sludges. (Paragraph 72).

460 Crude sewage should only be discharged to the sea after screening, comminution and through diffusers on long outfalls, when the siting has been determined after a comprehensive study of local factors. (Paragraphs 255 and 256).

461 The effects of dumping sludge and toxic and persistent substances to the sea should be monitored. (Paragraphs 60 and 267).

Education and training

462 Existing postgraduate courses in public health engineering and other relevant courses should receive greater support from qualified engineers and scientists working in water pollution control. The appropriate Training Board should help in financing this training. (Paragraphs 388–391).

463 Training courses for the Diploma Examinations of the Institute of Water Pollution Control and for operators of sewage treatment works should be organised and financially assisted by the appropriate Training Board. (Paragraphs 392–394).

464 The Water Pollution Research Laboratory should hold frequent courses on all aspects of water pollution control. (Paragraph 387).

465 Managers of sewage treatment works should be required to hold appropriate professional qualifications (Paragraph 393).

Research

466 Present allocation of funds to the Water Pollution Research Laboratory should be at least doubled; increased allocation should be made to other government research organisations concerned with water pollution and universities and sewage disposal authorities encouraged to carry out more research in water pollution control. (Paragraph 404).

467 A more positive policy should be made to implement the knowledge gained from research. (Paragraph 405).

468 Publicly financed research organisations concerned with all aspects of water should be placed under the control of a central water authority. (Paragraph 399).

469 Priorities for research should include: treatment and disposal of sewage sludge; treatment and disposal of farm wastes; the effects of mineral salts in polluted river water used for agricultural irrigation; methods of removal of nutrient salts and organic residues from polluted waters; and development of improved criteria for assessing pollution. (Paragraphs 401–403, 141).

Future Administrative Structure

470 The function of sewage disposal must be considered as part of the whole water cycle, together with water conservation and the control of the quality and quantity of flow in our waterways. (Paragraph 431).

Reservations of Ian Percival Q.C., M.P.

1. As you (the Ministers) will know, the doubt which I expressed to you before responding to your request that I should join this Working Party has materialised and I have missed many meetings. Indeed I have wondered whether I ought even to sign the report for there are at least two reasons why I am not entitled to share equally in the credit due to my colleagues, i.e.

(a) most of them have attended so many more of the 17 discussion meetings of the Working Party than I have; and

(b) many of them bring to the consideration of the technical questions a knowledge and understanding which I would not pretend to share despite the great assistance on such matters given to us laymen by our technical secretary Mr. Truesdale.

However, as you anticipated, it has been possible to compensate for physical absence by reading, for the documentation has been very full and very good. Accordingly, and because I agree with so many of the views expressed in the report I have signed it. I do so however subject to the following reservations.

2. Whilst I have some doubts on a number of points of detail ranging from terminology (eg I do not like parts of paragraph 158) to recommendations (eg I am not absolutely sure about 450, 451 or 454), I do not think it either (i) necessary to pursue such matters which are perhaps no more than the differences of detail which must arise amongst a Working Party of this size and variety or (ii) fair to the other members to do so as it may be that if I had been able to take more part in the discussions they might have persuaded me.

There are however three matters on which I must expressly reserve my position.

3. Advertisement of Discharges to Rivers

As the Working Party knows I am sceptical about the recommendation made in paragraphs 164 and 444. Presumably the purpose of advertising is to give persons who may be affected a chance and a right to object. If it were clear that that right was to be in addition to and not in substitution for any existing rights I should be content. If however the intention is that on the giving of such a right the common law rights of riparian owners or anyone else, should be abrogated or limited, I am strongly opposed to that. In my view the question of the possible effects of a proposed discharge could well be so technical, and indeed so problematical for even the technical experts, as to make advertisement and/or a right to object of very little value to most people. Accordingly, and since the terms of this recommendation seem to me to imply a consequent limitation of some other rights, I cannot agree with it.

4. Disposal to Sea

I share to the full the main conclusions reached by the Working Party, eg I agree that there are some places where the conditions are disgraceful and ought to be improved dramatically and with the maximum speed, and I too would like to see more treatment of sewage before discharge to the sea and/or the better siting of the outfalls through which it is discharged; but I differ from the views expressed in the report in the following respects.

I feel that in the main the problems arising from sewage on or near the beaches are localised rather than universal or even general—that around by far the greater part of the coast conditions are satisfactory—that where improvements are necessary the means of securing them are known—and that the main need is for better means of persuading those who will not, and helping those who cannot (eg because of cost), solve their own problems.

The number of beaches which can be described as being aesthetically revolting because of sewage is small and the risk to health from bathing in the sea is so small, even in the worst places, that it can be ignored. One of the biggest problems in both respects is the deposit of waste, including human waste, straight on the beaches by the public. The biggest single pollutant at the moment is probably oil.

Against that background I query the value, in the context of sewage disposal, of such statements as we make in paragraphs 228 and 241. As to 228 if we once depart from the standard test of "injurious to public health" there are probably as many standards as there are people. As to 241 the same difficulty arises as soon as one starts to *insist* on anything other than avoidance of risk to public health—plus (in both cases) the question of who pays.

I agree that there is a need for control of dumping at sea (not least the dumping of chemicals, and not only within the 3 mile limit); and so far as discharges of sewage to sea are concerned I can see the case for giving the Ministers and/or those concerned with coastal waters some more effective powers for speeding on the laggards and helping on the lame; but I do not agree:—

(a) that it is necessary or desirable to divide the whole coast into sections and bring it all under control as envisaged in the report; or

(b) with the Working Party's recommendations in paragraph 440 that the powers there set out or any powers in relation to discharge to or dumping at *sea* should be given to "the authorities responsible for water *conservation*", ie conservation of *fresh* water, a very different job.

5. Future Administration

I agree wholeheartedly with the last sentence of paragraph 431 and with the proposition that some new central body is required with an overall responsibility for planning the co-ordination of the conflicting requirements and interests of those concerned in the various parts of the water cycle; but nevertheless have substantial reservations about important parts of our Chapter 9.

One of my reservations relates to size. Whilst I appreciate that there may be many cases where an increase in size would conduce to greater efficiency I do not accept the general proposition that the two go together. On the contrary I should have thought that there were quite enough inefficient monsters at work to disprove that proposition. But my principal reservation springs from the use of the word "integration" and the terms of paragraph 430. Strongly as I favour co-ordination I shrink from the thought of new monsters owning, managing and/or directing everything from the local sewers upwards, over an area loosely described as the catchment area of the river, and insofar as that is what is meant by "integration" and the terms of paragraph 430, I remain unconvinced of either the necessity for or wisdom of such a course.

Further since such a proposal would appear to involve taking sewage disposal out of the hands of those who are now responsibile for it and adding it to the responsibilities of the River Authorities—or their successors, the new "authorities responsible for water conservation" referred to in the report—it does seem to entail the entire restructuring of the administration and financing of sewage disposal and I should like to hear the views of all presently concerned with this work *directed specifically to the suggestions made in this part of our report*, before reaching even such general conclusions as are expressed in it.

Accordingly whilst I view the suggestions made in Chapter 9 as interesting ones worthy of consideration in any future discussion of administrative structures, I personally would not wish them to be regarded as any more than that at the present.

Generally

Needless to say nothing in the foregoing should be taken as any indication of weakness. I agree wholeheartedly with the urgent desire of my colleagues, (which, happily, is also becoming the objective of a substantial proportion of the public) to clean up Britain. Like them I want to see all forms of pollution, (especially perhaps the desecration of public beaches and parks by waste, including human waste), reduced to a minimum.

So far as pollution by sewage is concerned, I am as keen as the keenest of them to reduce this, not least because I know from my own constituency how well it can be done provided the intention is there and funds are available. My differences, such as they are, are as to emphasis and means, *not* intentions or objectives.

Reservations of Councillor W. Wroe, J.P.

Members of the Working Party are aware that on a number of occasions I have expressed doubts with regard to the proposed new administration.

I have signed the report, subject to a similar reservation to that expressed so adequately in paragraph 5 of Mr. Ian Percival's note of reservation. That paragraph is one to which I fully subscribe.

to in the report—it does seem to entail the entire restructuring of the administration and financing of sewerage and I should like to have … of all presently concerned with this work directed specifically to the … *in this part of our report*, before reaching even … conclusions as are based on it.

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… a proposal would appear to involve … of the hands of … who, … to the … their successors, the new … conservation" referred …

… aware that … with regard …

… a similar reservation …

Appendix 1 List of bodies and people who submitted evidence

Government departments and organisations

Board of Trade (Industries Division)

Countryside Commission

Ministry of Agriculture, Fisheries and Food (Fisheries Division and Agricultural Advisory Service)

Ministry of Technology (Water Pollution Research Laboratory)

Ministry of Transport (Highways and Inland Waterways)

Natural Environment Research Council (via Department of Education and Science)

Science Research Council (via Ministry of Technology)

Water Resources Board

Public corporations

British Railways Board

Central Electricity Generating Board

Electricity Council

English Industrial Estates Corporation

National Coal Board

Port of London Authority

Local authority associations

Association of Municipal Corporations

Association of River Authorities

Association of Sea Fisheries Committees of England and Wales

County Councils Association

National Association of Parish Councils

Rural District Councils Association

Local authorities

Bolton and District Joint Sewerage Board

Bournemouth County Borough

Broadstairs and St Peter's Urban District Council

Chichester Rural District Council

Felixstowe Urban District Council

Greater London Council

Lancashire River Authority

Lowestoft Borough Council

Poole Borough Council

Southern Sea Fisheries District Committee

West Sussex County Council

Other associations

Association of County Public Health Officers

Association of Public Health Inspectors

Association of River Inspectors of Scotland

British Leather Manufacturers' Research Association

British Medical Association

British Sewage Plant Manufacturers' Association

British Waterworks Association

Camping Club of Great Britain and Ireland

Chemical Industries Association Limited

Chichester Constituency Liberal Party

Coastal Anti-Pollution League

Confederation of British Industry

Council of British Ceramic Sanitaryware Manufacturers

Country Landowners' Association

Dock and Harbour Authorities' Association

Farm and Food Society

Institute of Water Pollution Control

Institution of Civil Engineers

Institution of Municipal Engineers

Institution of Public Health Engineers

Institution of Water Engineers

National Farmers' Union

National Federation of Anglers

National Federation of Women's Institutes

National Union of Ratepayers' Associations

National Union of Townswomen's Guilds

PIRA (The Research Association for the Paper and Board, Printing and Packaging Industries)

Ramblers' Association

Royal Institute of Public Health and Hygiene

Royal Society of Health

Salmon and Trout Association

Shellfish Association of Great Britain

Society of Chemical Industry

Society of Medical Officers of Health

Wales Tourist Board Limited

Water Research Association

Wool Textile Delegation

World Health Sanity and Hygiene Trust

Firms

Constructors John Brown Limited
Imperial Chemical Industries Limited
Richard Hodgson and Sons Limited
Wingham Contruction Limited

Individuals

Mr H. Button
Dr E. G. Coker
Dr R. Darnell
Sir William Dugdale
Mr W. Fyffe
Councillor C. H. De Peyer
Mr F. Smith
Mr H. D. Thatcher

Appendix 2 Expenditure on Sewerage and Sewage Disposal

1 The figures which will be quoted are confined to public expenditure as the cost incurred by private firms for treating their own effluent before discharge are not known. The figures include the costs of sewerage as well as of sewage disposal.

Overall expenditure

2 The latest figures for England and Wales show expenditure on current account of about £98 million and on capital account of £100 million for 1968–69. The total expenditure amounts to about 0·5 per cent of gross national product. In 1938–39 it amounted to about 0·4 per cent and then fell drastically during the war to 0·26 per cent rising to the prewar proportion by 1961–62. Total expenditure at 1968 prices has about doubled during the last 10 years and is still rising despite the controls. The expenditure by river authorities on controlling pollution amounts to about £1 million a year. This is met by precepts on local authorities.

Local variations in expenditure

3 Specific Exchequer grants for sewerage currently amount to about 4 per cent of local expenditure; Exchequer grants as a whole cover rather more than half of overall local authority expenditure. The figures quoted below show the actual expenditure without deduction of Exchequer grants.

4 The estimated local expenditure per head of population for sewerage and sewage disposal, and the total local expenditure per head, by type of local authority, are shown for 1967–68.

Estimated average expenditure per head

	Sewerage and sewage disposal		**All services**	
	s	d	s	d
County Boroughs	30	5	1,120	5
Inner London Boroughs	41	2	1,658	3
Outer London Boroughs	29	10	1,240	4
Non-County Boroughs	36	11	1,312	7
Urban Districts	36	4	1,201	1
Rural Districts	56	1	1,010	7

(Source: Institute of Municipal Treasurers and Accountants (IMTA). Return of rates 1967–68 which includes all county boroughs, London boroughs and a large and representative selection of non-county boroughs, urban districts and rural districts).

5 There are extreme variations within these averages.

	Expenditure per head				**Rate in the £1**			
	Highest		Lowest		Highest		Lowest	
	s	d	s	d	s	d	s	d
Boroughs (outside London)	108		3	2	3	4		1
Urban districts	133		4	2	3	8		1
Rural districts	137		6	7	5	11		3

6 The extent of debt charges on the sewerage account is a major variable in local expenditure. Debt charges run for 15 years for plant, 30 years for buildings and 30–50 years for sewers. Local authorities which are renewing a large part of their sewage system or are sewering a large part of their area for the first time can incur charges on the rates amounting to several shillings in the £1. There are small coastal or estuarine authorities who have been considering the construction of a better method of sewage disposal but have been deterred by the cost in relation to their resources.

7 Other variations in cost are due to differing lengths of sewer per house, differing pumping requirements, and different qualities of influent and effluent at the sewage works. Larger works are on the whole cheaper to operate, but may require more expenditure on sewerage.

8 The recent IMTA analysis of the cost of sewage disposal works serving more than 20,000 people shows the same wide variation in costs. The costs of treatment range from a few pence per 1000 gallons of dry weather flow to over a hundred pence. Similarly the costs per 1,000 population served by each works range from £100 to over £3,000. An estimate for the cost of new works is £20–£30 per head of population served.

9 Some of the high costs quoted would of course be greatly relieved where a local authority is receiving enough from the Exchequer under the resources element of the rate support grant to cover a large proportion of its expenditure, but even so the rate levied to meet the sewerage account can be high. If areas were larger, there would naturally be less variation in the local costs of sewerage and sewage disposal.

Appendix 3 Measurement of Pollution

1 When sewage or other organic wastes are discharged to a watercourse there is a reduction in the concentration of dissolved oxygen in the receiving water owing to its absorption by bacteria in the presence of the organic matter. The bacteria utilise this organic matter as food for their growth, causing it to be broken down into simpler organic and inorganic compounds. If the organic pollution load is sufficiently great, the stream may lose all its dissolved oxygen, when putrefaction, and foul odours, due to liberation of hydrogen sulphide gas, result. It is therefore of the greatest practical importance to have a knowledge of the amount of organic matter present. Thus, many of the tests used in sewage analyses estimate the concentration of organic matter. Since organic matter in general takes up oxygen fairly readily, the amount of oxygen absorbed can be used as a rough measure of the organic content of the sample. One such test, which is widely used, is the 'Biochemical Oxygen Demand'' (BOD) test, originally devised by the Royal Commission on Sewage Disposal (1898–1915)[1] but since considerably refined. As its name implies it is a biochemical test dependent upon the activities of certain bateria, which in the presence of oxygen feed upon and consume organic matter: other bacteria cause ammonium compounds to be oxidised to nitrate (see below). The BOD test expresses the amount of oxygen used by the sample (usually diluted with sufficient well-oxygenated standard water) when incubated at 20°C for 5 days; it does not measure any specific constituent of the polluted sample. The test, in some measure, simulates natural conditions in a river.

2 Other methods used for assessing the amount of organic matter in liquid wastes are the 'Permanganate Value', the 'Chemical Oxygen Demand' and the direct measurement of organic carbon. Of these various tests, the BOD, despite certain limitations, has been found to be the most useful single test of the strength of sewage. When taken in conjunction with the determination of the amounts of solids in suspension (which are largely organic in nature) and of ammoniacal nitrogen in solution, it is possible to form an estimate of the size of treatment works needed to treat a particular sewage, to determine the performance of the various units and to assess the quality of the final effluent.

3 During the purification of sewage, or when sewage is discharged to a watercourse, nitrogenous organic matter is decomposed to ammonium compounds and then oxidised to nitrite, and finally to nitrate, by bacteria in the presence of dissolved oxgyen; this oxidation is termed nitrification and is brought about by nitrifying microorganisms which are not the same as those which oxidise carbon compounds. The relative proportions of the various forms of nitrogen indicate the degree of purification of the polluting sewage organic matter. Ammonia in discharges to watercourses will thus utilise dissolved oxygen, though will not of itself make the river anaerobic, and if in sufficiently high concentrations may be toxic to fish. It is therefore necessary to determine its concentration together with the corresponding nitrate present. In a fully treated effluent all, or nearly all, the ammonia is oxidised and its content is consequently low.

4 In the oxidation of polluting matter by microorganisms, carbonaceous material is first broken down, followed by oxidation of ammonia to nitrate by the nitrifying bacteria. Thus there is an oxygen demand exerted by carbonaceous matter and a further demand caused by the oxidation of ammoniacal compounds and of nitrate. The BOD test does not, unless precautions are taken, differentiate between the oxgyen consumed in these two distinct processes. Consequently, sewage effluents which are in a state of incipient nitrification—that is, oxidation of ammonia has started but is not complete—may give higher values of BOD and yet be of better quality than effluents in which nitrification has not become established and no ammonia has been oxidised. Thus, although the BOD test is useful and is widely used, results must be carefully interpreted. In the wrong hands misleading conclusions can be drawn.

5 The daily domestic pollution load per head of population is represented by about 0·13 lb (59g) BOD and the solid matter also by about 0·13 lb (59g)[2]. The strength of the sewage depends on the volume of water carrying the load. The daily dry weather flow of domestic sewage per head varies between about 25 gal (115 l) with a BOD of about 500 mg/1, and about 50 gal (230 l) giving a sewage with a BOD of about 250 mg/1.

6 Other important analytical measurements which are commonly made include the determination of certain toxic materials such as metal and cyanides, which are derived from some trade wastes.

7 Direct tests on the toxicity of effluents may be made using standard techniques. Where filter-feeding shellfish are present, pollution is measured by determining the coliform bacteria and *Escherichia coli* (*E. coli*) counts in the water and in the shellfish.[3,4]

8 Changes in domestic habits bring about alterations in the composition of domestic sewage. For example, as a consequence of the widespread use of synthetic detergent powders, the active constituent of such preparations is now present in domestic sewage in Britain in quantities amounting to about 0·006 lb (2·7g) per head per day. The increase in these materials has been accompanied by an increase in the phosphate and boron contents of sewage arising from the polyphosphate and perborate additives in the detergent powder.

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Appendix 4 Sewage Treatment Processes

Primary treatment

1 Sewage is usually first passed through a series of bar screens in order to intercept wood, rags and other debris. The screenings may be removed mechanically and buried or burnt, or they may be disintegrated (comminuted) and returned upstream of the screens. An alternative method to the use of screens is to pass the sewage through a comminuter or disintegrator which cuts the solids up into small pieces.

2 Removal of grit from the sewage is effected by means of a small settlement tank or by passing the sewage along a constant velocity channel. In either case the grit deposited should be in a fairly clean condition, the lighter organic matter being carried forward. The deposited grit may be removed by mechanised devices; it consists of sand together with a small proportion of organic matter. (The sequence of screening and grit removal is reversed at some works.)

3 The next stage is the removal of the settleable solids. This is achieved by the process of settlement or sedimentation, whereby the sewage is passed through large tanks so slowly that the settleable particles settle out and are removed in the form of a liquid sludge, whilst the settled sewage passes forward. Sedimentation tanks at sewage works are either rectangular (horizontal flow), or circular (radial flow) as in Diagram 3, page 8, or square (vertical flow) in plan and are normally equipped with mechanical desludging gear. The general practice nowadays is to install relatively shallow radial flow tanks. Depending on the nature of the sewage, this stage of treatment can, if properly designed, be effective in removing between 60 and 80 per cent of the settleable solids from the sewage, and perhaps, one-third of the oxygen demand.

Secondary treatment

4 The organic matter normally left in sewage after sedimentation is readily oxidised or otherwise converted into harmless substances by the bacteria and organisms present in the sewage itself. To enable this process to proceed sufficiently rapidly, the bacteria must be brought into intimate contact with the sewage impurities in the presence of atmospheric oxygen in such a way that the resulting solid products of reaction (which also contain much of the bacteria and other purifying organisms) can readily be separated from the liquid before the latter is either discharged (as purified effluent) to a stream, or is given further (tertiary) treatment. To carry out this purification two main methods are used, biological (percolating) filters and activated sludge.

5 Biological filtration has been used to purify sewage and industrial wastes in Britain for at least 80 years. This process was developed to solve the difficulties associated with the treatment of sewage on land. The sewage liquor from the sedimentation tanks (settled sewage) is distributed over the surface of a bed of graded inert medium supported on underdrains designed to allow access of air to the bed. A gelatinous film containing bacteria and fungi forms on the surface of the medium and purification takes place as the sewage percolates downwards over these biologically active surfaces, the organisms in the film attacking and oxidising the polluting matter. In its simplest form the conventional filter is about 6ft (2m) deep and is filled with any durable granular medium, broken rock, gravel, slag and clinker being the most commonly employed materials. The word 'filter' is a misnomer, since the process is not designed to filter out suspended solids. Its function is to present an extended surface on which the necessary bacteria and sewage can be brought into intimate contact in the presence of air.

6 The effluent from the filter contains particles of detached film—which is continually growing in the filter—and other solid matter known as 'humus', which is removed by further sedimentation. After this treatment the liquid is comparatively clear and inoffensive and is either discharged directly to a watercourse or is given further treatment.

7 In this country it has been customary to operate filters at low loadings and so reduce the oxygen-consuming matter (BOD) in the settled sewage by between 90 and 95 per cent to produce a nitrified effluent of 30:20 standard. This is achieved at many works by using single-pass filters, in which sewage is applied at the top and oxidised liquid discharged at the bottom. Other works take advantage of comparatively recent developments of the process, namely recirculation and alternating filtration (ADF). In recirculation systems the settled sewage fed to the filters is diluted with an equal volume (or more) of purified effluent which has passed through them once before. In the ADF process the filters are operated in series. The settled sewage is applied at a relatively high rate to the primary filter, and its effluent, after settlement, is then passed to the secondary filter. At intervals ranging from daily to weekly, the order of the filters is reversed. Both recirculation and ADF systems have the advantage over single-pass filters of enabling a greater volume of sewage to be applied to a given volume of medium; on the other hand the oxidation of ammonia is usually less.

8 In the past few years attention has been directed towards high rate filtration of anything up to 20 times the normal standard loading, as a partial treatment stage. Such treatment may remove up to 70 per cent of the BOD, and a second biological stage of treatment—either filters operated at low loading or activated sludge—is required if a good-quality effluent is to be produced. This two-stage method of treatment appears to have some distinct advantages, particularly where it is necessary to produce a well-nitrified effluent. For the high-rate ('roughing') filtration stage, the medium is of a large size, 4–6 in (10–15 cm), compared with 1½–2½ in

(3·8–6·3 cm) for low-rate filters. Alternatively, modules of plastic sheet material are being increasingly used for this purpose, particularly for industrial wastes. This material is at present expensive, but has the advantage of being able to deal with high loadings of polluting matter without becoming blocked with biological film.

9 For the very small community of a few houses, two methods based on biological filtration principles have been developed and marketed in this country: the extended filtration process which utilises plastic medium and a high recirculation rate, and a disk filter which provides a biological surface on a series of rotating disks, the lower portions of which pass through a trough of the waste liquid.

10 Where large volumes of sewage are to be treated to a high standard, treatment by conventional biological filtration may occupy too much land. In such cases biological treatment is achieved by use of the activated sludge process as in Diagram 3, and in fact this is the process which is normally employed for works serving 50,000 people and nowadays for even smaller populations.

11 In this process, the settled sewage is aerated in tanks, by compressed air or mechanical agitation, in the presence of 'activated' sludge—a flocculent settleable sludge consisting of cultures of micro-organisms which gradually accumulates in these conditions. The aeration of this mixed liquor is continued for several hours, during which the colloids become flocculated and the impurities in the sewage undergo biological oxidation. The sludge is then separated from the purified sewage by settlement in tanks, and a portion of it is returned to the aeration tanks to treat more sewage. The excess sludge which is continually accumulating during the process is withdrawn for disposal elsewhere.

12 Several methods are used for introducing oxygen from the air and mixing the sewage and activated sludge so as to keep the sludge in suspension. But in this country where generally plants are required to produce an effluent of a high standard, the following two systems are mainly employed:

1 air diffusion systems, in which air is blow through the mixed liquor, and

2 mechanical aeration systems, in which atmospheric oxygen is introduced into the liquid and the activated sludge is kept in suspension by an agitator rotating at or near the surface of the liquid.

13 A number of modifications of the conventional activated sludge process have been introduced in this country over the past few years. These include the extended-aeration process, the contact-stabilisation process, the oxidation ditch, and the "Lubeck" process. All the processes treat unsettled crude sewage and provide at some stage of treatment a long period of aeration of the sludge in order to bring about a reduction in the amounts for ultimate disposal. The "Lubeck" process operates with loadings some four times greater than with conventional plant. In contrast the other three processes operate with lower loadings, that of the oxidation ditch being only about one-third of a conventional plant; they are used principally for treating small volumes of waste from small communities, though the contact stabilisation process is suitable for use at larger works.

Choice of biological process

14 Each of the two methods of biological filters and activated sludge offer advantages and disadvantages. Filters are usually higher in capital cost but lower in running costs than activated sludge plants, and for most proposed schemes the estimated annual costs, (that is loan charges plus operating and maintenance expenses) are not greatly different for the two methods.

15 Where it is necessary to produce an effluent of high quality, the area of land required for conventional filter schemes is about ten times that needed for an activated sludge plant to treat the same pollution load. This ratio may be reduced considerably by employing high-rate filtration processes. For plants required to treat large flows, the smaller area required for activated sludge is the deciding factor and in recent years the maximum size of new plants employing biological filters has been decreasing. On the other hand filters are more robust and recover more quickly from interference by toxic materials in the sewage than do activated sludge plants. They also require less skilled and close control, and are therefore more suitable for small works where technical facilities are limited.

16 Filter installations are prone to breed flies, which may give rise to nuisance and they are normally more conspicuous than activated sludge plants. On the other hand some activated sludge plants can be noisy and this can be an important amenity consideration.

Tertiary treatment

17 Conventional biological treatment can produce an effluent which is usually of a suitable standard for discharge to a watercourse, but for reliable production of higher quality effluent, a tertiary or "polishing" stage of treatment is necessary. These "polishing" processes rely mainly on flocculation, sedimentation or filtration of much of the residual suspended solids which have escaped sedimentation during secondary treatment. The BOD associated with the suspended matter is also removed.

18 Several "polishing" methods are now used at sewage works. They include surface irrigation over grass plots, slow sand filtration, retention in lagoons, microstraining, rapid sand filtration and upward-flow gravel clarifiers[1]. The efficiency of the various methods differ, but by applying a suitable process to a well-oxidised secondary effluent, it is possible to reach a 10:10 standard (10 mg/l suspended solids, 10 mg/l BOD) of quality.

19 Certain of these polishing processes (notably lagoons and grass plots) are also effective in reducing the bacteria content of sewage effluents. The numbers of bacteria remaining are of special importance where the effluent is discharged into coastal waters in which filter-feeding molluscan shellfish are harvested for food. In this respect, storage in long retention lagoons can reduce the numbers of bacteria by up to 99·5 per cent and grass plots up to 90 per cent of the content of the influent.

Sludge treatment

20 Sludge comprises grit, 'primary' sludge deposited in the sedimentation tanks, and 'secondary' sludge resulting from the biological treatment processes. This sludge is a highly putrescible, evil-smelling, thick liquid containing the solid matters of the sewage dispersed in many times their weight of water. These solids are difficult to separate from water. Disposal of this material (amounting to rather more than half of one per cent of the initial volume of sewage) accounts for about two-fifths of the total cost of sewage treatment. The crude mixed sewage sludge, as withdrawn from sedimentation tanks, has a solids content of up to 4·5 per cent and this has to be "dewatered" to reduce the bulk before final disposal.

21 It has been estimated[2] that on average some 25 tons of dry sewage solids is produced per annum from the sewage from 1,000 persons. Since, in England and Wales, sewage from about 40 million people receives full treatment at municipal works, the total amount of dry sludge to be disposed of each year from these works is about one million tons. The amount of wet sludge as withdrawn from the sedimentation tanks will, however, be more than 20 times this figure. In actual fact the quantity of dry solids will be greater than one million tons a year, since a considerable proportion of the sewage from the 3 million people in rural areas served by septic tanks and cesspools, is transported to municipal works for treatment.

22 The most convenient and economical method of disposal at any given site depends on many factors, not least the location of the works. Some of the larger towns on estuaries convey sludge, usually after treatment, to dumping areas at sea, using special vessels. At inland towns, conveyance of sludge to the sea would be prohibitively costly and it is mainly disposed of on land, usually after treatment and "dewatering."

23 The most widely used process for treating sludge is by anaerobic digestion (shown in Diagram 3), which consists of storing sludge for several weeks in closed tanks heated to 35°C. This process depends on the activities of a number of varieties of bacteria which flourish in the absence of air. As a result of the biochemical changes which they bring about, the sludge is transformed into inoffensive humus-like material, and more than one-third of the solids content is converted into gas, consisting of carbon dioxide and methane, which is a useful fuel. The treatment also destroys many pathogenic organisms. Sludge is therefore converted into a product suitable for application to agricultural land.

24 The process however can be upset by certain chemical constituents of waste waters and efficient trade effluent control is necessary for its satisfactory operation. A recent nation-wide survey[3] by the Ministry of Technology's Water Pollution Research Laboratory, has revealed that anaerobic digestion gives good results when satisfactory equipment is available and is operated efficiently. Synthetic detergents, discharged mainly from domestic premises, have caused some troubles, but the survey revealed that serious cases of difficulty were quite rare. The laboratory has developed a method, which has been successfully applied at a few works, to overcome problems arising from detergents.

25 Digested sludge can be "dewatered", if required, much more readily than can the original sludge. Other works use chemical conditioners or heat treatment to 'condition' the sludge before drying. When certain chemicals are mixed with sludge, solids coagulate and water is released. Heat treatment involves the heating of sludge under pressure to temperatures of 180–200°C. The process is applicable to all types of sludge and sterilises the product. It does, however, convert a proportion of the sludge solids into soluble matter to produce a very strong liquor which requires further treatment usually before being mixed with the incoming sewage.

26 The traditional method in this country of dewatering sludge is by air drying on open beds. This process occupies comparatively large areas of land (half a sq yard ($\frac{1}{2}$m^2) per person served) and is entirely dependent on the weather. During the summer the sludge may be fit for removal in a couple of weeks after application, but in the winter, when evaporation ceases, it may be six months before sludge can be removed. Drying beds often give rise to offensive smells. Their continued use at the present scale is undoubtedly due to developments in mechanisation which permit automatic lifting and conveying of sludge cake and the re-sanding and levelling of beds with only small labour requirements.

27 Mechanical methods are also used it "dewater" sludge; they are entirely independent of the weather, are flexible in operation and require only a small area of ground. Methods include pressure filtration, vacuum filtration and the sludge concentrator. Filter pressing is the oldest British method of mechanical dewatering and consists of pressing the sludge between filter cloths at fairly high pressures. The method has the advantage of permitting the direct and practically complete removal of suspended solids from the crude sludge, thus avoiding the necessity for recirculation of polluting matter inherent in some other methods of treatment.

28 Vacuum filters are a more recent development and are used at a few works in this country, though they are popular in the U.S.A. In this process water is sucked from the sludge under vacuum through a filter cloth carried on a slowly revolving drum partly immersed in the sludge. The limited application of the method in Britain is attributed to the difficult nature of our sludges due to the high proportion of secondary sludges which they contain. Before either pressure or vacuum filtration is carried out, the sludge is conditioned by washing with treated effluent and/or by treatment with chemicals.

29 In the sludge concentrator, liquid sludge is fed continuously into rotating open-ended drums covered with nylon fabric. The solids form into a cylindrical plug and the liquid drains through the fabric. As the plug increases in size the ends are cut off and fall into a compression filter, where more water is squeezed out. The recovery of solids is reduced if the sludge contains appreciable quantities of difficult secondary sludges, although this problem has recently been overcome by using conditioning chemicals. The concentrator is used at several of the smaller and medium-sized works.

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Glossary of Terms, Definitions and Units

TERMS AND DEFINITIONS

Activated sludge	Flocculent sludge produced by the growth of bacteria and other organisms in raw or settled sewage when it is continuously aerated.
Activated sludge process	A biological sewage treatment process in which a mixture of sewage and activated sludge is agitated and aerated. The activated sludge is subsequently separated from the treated sewage by sedimentation and may be re-used.
Adsorption	The adherence of dissolved, colloidal or finely divided solids on the surface of solid bodies with which they are brought into contact (as distinct from "absorption").
Aeration	The bringing about of intimate contact between air and liquid by one of several methods, ie spraying the liquid in the air, forcing air through the liquid, agitating the liquid to promote surface absorption of air.
Bacteria	Primitive organisms which reproduce by division:
i. aerobic bacteria	Bacteria which require free oxygen for their growth.
ii. anaerobic bacteria	Bacteria which grow in the absence of free oxygen and which derive oxygen by breaking down complex substances.
iii. coliforms	A group of bacteria whose absence from drinking water is regarded as a guarantee of freedom from harmful bacteria.
iv. E coli (Escherichia coli)	An organism of the coliform group which inhabits the human and animal intestine. If this is absent, water may be passed as safe even if a few coliforms are present: but no coliforms should be present in water which has been chlorinated.
Biochemical oxygen demand (BOD)	The amount of dissolved oxygen consumed by chemical and microbiological action when a sample is incubated for 5 days at 20°C. (The BOD normally gives a rough indication of the organic matter present in the sample).
Biological filter	See "percolating filter".
Catchment area (or catchment basin)	The area draining naturally to a given point.
Chemical oxygen demand (COD)	The amount of oxygen used in the chemical oxidation of the matter present in a sample by a specified oxidising agent under standard conditions.
Chlorination	The application of chlorine to water, sewage or industrial waste generally for the purpose of disinfection.
Colloidal material	Finely divided solids which will not settle but may be removed by coagulation.
Combined system	A system of drainage in which foul sewage and surface water are carried in the same drains and sewers.
Detritus tank	A tank in which sand, grit and other heavy inorganic materials are removed by sedimentation from sewage.
Digestion	The biochemical decomposition of organic matter using anaerobic bacteria, which results in the formation of simpler and less offensive organic compounds.
Drainage area	The area actually draining to a given point, which may or may not coincide with the "catchment area".
Dry weather flow (DWF)	1. The sewage together with infiltration, if any, flowing in a sewer in dry weather: 2. The rate of flow of sewage, together with infiltration if any, in a sewer in dry weather.
Effluent	Any liquid which flows out of a containing space, but more particularly the sewage or trade waste, partially or completely treated, which flows out of a treatment plant. For example, sewage effluent is the liquid finally discharged from a sewage treatment works.
Eutrophication	The enrichment of water in watercourses and lakes by chemical substances, especially compounds of nitrogen and phosphorous. It can greatly accelerate the growth of algae and higher forms of plant life.
Final settlement tank	A tank through which the effluent from a percolating filter, or aeration tank, flows for the purpose of separating settleable solids. The former is often called a "humus tank".

Ground water	Water contained in the soil or rocks below the standing water level or water table.
Humus tank	See "final settlement tank".
Hydrological cycle	The full course of water movement, comprising evaporation from the sea, precipitation upon the land, percolation into underground strata, etc; and the eventual flow of water back into the sea.
Impounding reservoir	A reservoir in which the natural flow of a stream is stored, for example, one formed by a dam across a valley.
Industrial effluent	Water-borne wastes from industry.
Infiltration	The unintended ingress of ground water into a drainage system.
Influent	Water, sewage or other liquid, raw or partly treated, flowing into a reservoir, basin or treatment plant.
Intercepting sewer	A sewer which receives flows from a number of transverse sewers or outlets.
Outfall	The point at which a sewer or land drainage channel discharges to the sea or to a river.
Oxidation	The chemical change which a substance undergoes when it takes up oxygen.
Partially-separate system	A modification of the separate system in which part of the surface water is conveyed by foul sewers.
Pathogens	Bacteria capable of producing diseases.
Percolating filter	An artificial bed of inert material over which sewage is distributed and through which it percolates to underdrains, thus giving an opportunity for the formation of biological slimes which bring about oxidation and clarification of the sewage. Sometimes referred to as a trickling filter or bacteria bed.
Potable (adjective)	Of water which has been treated so as to render it bacteriologically and chemically safe to drink and which has no unpleasant taste or smell.
Royal Commission Standard	BOD of 20 mg/l and suspended-solids content of 30 mg/l: the normal minimum criteria for effluents discharged into inland watercourses. (See Chapter 2, paragraph 39).
Sedimentation tank	A tank in which water or sewage containing sediment is retained for a sufficient time at a sufficiently low velocity to remove part of the sediment by gravity.
Separate system	A drainage system in which fouled sewage and surface water are carried in separate pipes.
Settlement tank	Another name for a "sedimentation tank".
Sewage	The contents of sewers carrying the water-borne wastes of a community.
Sludge	The accumulated solids produced during the treatment of sewage.
Sludge digestion	The process by which organic or volatile matter in sludge is converted partly into gas and partly into more stable organic matter by the action of bacteria.
Slurry	Solids mixed with water.
Storm overflow	A device on a combined or partially-separate sewerage system, introduced for the purpose of relieving the system of flows in excess of a selected rate, the excess flow being discharged to a convenient watercourse.
Suspended solids	The solids which are suspended in a sewage or effluent.
Water table	The level below which the soil or rocks are saturated with water; unlike the surface of water exposed to air a water table may be undulating.

UNITS — British units have been used in our Report. But in view of the forthcoming change to the metric system in the United Kingdom, we have included, where appropriate, the metric equivalents in brackets.

Volume

mil gal	million gallons
(l	litres
m^3	cubic metres)

Length

in	inches
ft	feet
(m	metres
km	kilometres)

Weight

lb	pounds
tn	tons
(mg	milligrams
g	grams
kg	kilograms)

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A borrower will be considered liable for the value of any publication lost or damaged while on loan to him, and, if it be a single volume or part of a set, for the value of the whole work thereby rendered imperfect. Marking or writing in the publications is not permitted, and borrowers are requested to call attention to damage of this character.

Books and pamphlets may be retained for twenty-eight days. Periodicals may be retained for fourteen days. Applications for extension of the loan period must be made in writing before its expiry. No publication may be kept longer than three months.

Books and pamphlets added to the library will not be lent until after the expiry of one month from the date received. The current number of a periodical may not be borrowed.

Borrowers retaining publications longer than the time specified, and neglecting to return them when demanded, forfeit the right to borrow until they be returned, and for such further time as may be ordered by the Council.

Any borrower failing to comply with a request for the return of a publication shall be considered liable for the cost of replacing it, and the Council may, after giving due notice to him, order it to be replaced at his expense.

No publication may be reissued to the same borrower until at least seven days have elapsed after its return, neither may it be transferred by one borrower to another.

Publications may not be taken or sent out of the United Kingdom.

Publications returned through the post must be securely packed and adequately protected.

The library may be used for reference by members during the office hours of the Society.

Publications borrowed through the post must be acknowledged on the form provided, immediately upon receipt, and returned when due to the Librarian at the above address.

January, 1968.

O.B., Truro.